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HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA  
MINE HOIST OPERATOR TRAINING PROGRAM. INSTRUCTION MANUAL. (U)  
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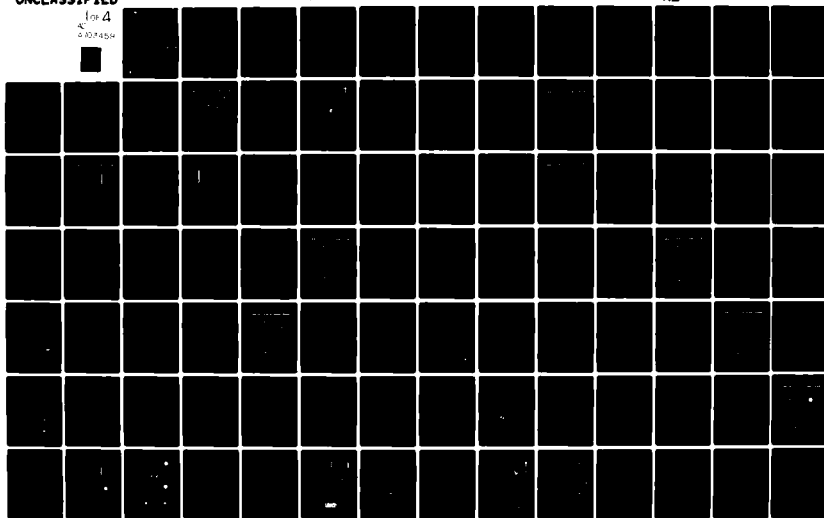
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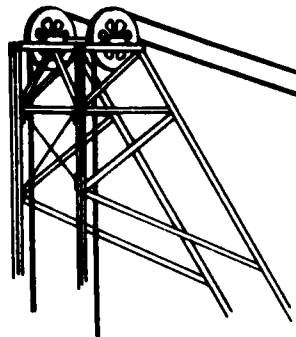
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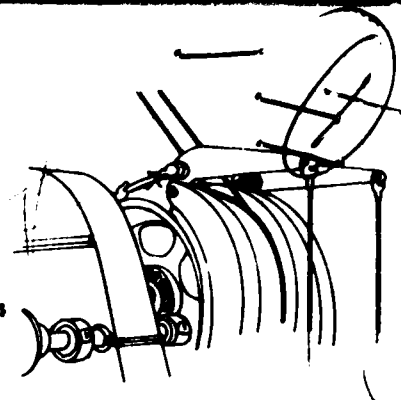
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# Mine Hoist Operator Training Program

Instruction Manual

*Dec. 1979*

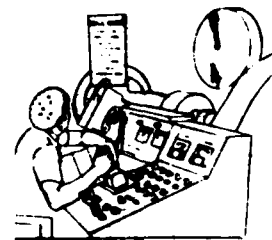
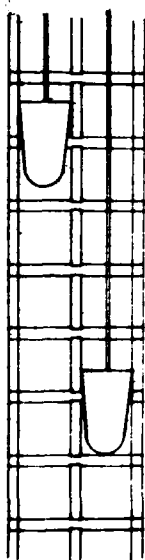
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THIS MANUAL CONTAINS:

Program Table of Contents

Instructions for the Instructor or Monitor

Instructions for the Student



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DTIC FILE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
<p>The purpose of this program is to train and re-train mine hoist operators. The training is in three parts. Part I the student will learn the basic components and operations of a mine hoist; in Part II the student will learn the specific components of the hoist they are being trained to operate; and Part III the student will become skilled in operating their assigned hoist.</p> <p>Test Question Booklet and Test Answer Booklet are separate</p>		

## FOREWORD

This training program was developed, produced and validated under U.S. Bureau of Mines Contract No. H0387003. Mr. William J. Wiehagen of the Bruceton Research Center was the Project Officer.

The work was performed by personnel of the Eastern Division of the Human Resources Research Organization of Alexandria, Virginia. Dr. Robert J. Seidel is the Division Director. Principal participants were:

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## **INSTRUCTIONS FOR THE INSTRUCTOR OR MONITOR**

The purpose of this program is to train and re-train mine hoist operators. The training will be in three parts.

- In Part I the student will learn the basic components and operations of a mine hoist.
- In Part II the student will learn the specific components of the hoist that he/she is being trained to operate.
- In Part III the student will become skilled in operating his/her assigned hoist.

In order to stimulate student interest, Parts I, II and III may be covered concurrently. For example, after the student has completed the basic unit on conveyances in Part I, he/she may be directed to complete the section on conveyances in Part II.

Similarly, after completing a basic operations unit in I, he/she may be directed to the hoist operator for training on that unit of Part III.

### **PART I – GENERAL**

Part I contains 24 units. Each unit describes:

- A basic component or system of a mine hoist, or
- A set of operating procedures

Each unit in Part I is a manual designed primarily for self-instruction and is administered by a course monitor. Each manual contains:

- A title page stating the title of the unit, the training objective (what the student is expected to know on completing the unit), and the time in hours to complete the unit.
- A list of the instructional objectives (the specific knowledge needed to attain the training objective and the level of proficiency required).
- The instructional material which describes the component, systems or procedures.
- Federal regulations that apply to the unit's subject matter.
- Practice questions that will reinforce the student's learning.
- Answers to the practice questions so the student can evaluate his/her own performance.

Test questions to measure the student's learning are provided in a separate booklet. The program monitor will give the student the test when the practice questions are completed. A second booklet contains test answers.

### **PART I – ADMINISTRATION**

Part I is designed to be administered as a self-instruction program. However, if the number of students warrants the use of an instructor, it can be administered as a classroom program.

### **Part I as a Self-Instruction Program**

- The program monitor gives the student a learning unit.
- The student reads the instructional material and answers the practice questions.
- The student may use the text to refresh his/her memory.
- The student checks the answers after all questions are answered.
- Incorrect answers are reviewed and corrected.
- When all practice questions are answered correctly, the student notifies the program monitor.
- The program monitor gives the student the test questions which are to be answered without using the text.
- The monitor grades the test upon completion.

### **Part I as a Classroom Program**

- The instructor will use the text as lecture material augmented with slides. The slides will be the same as the Figures in the text.
- On completion of the lecture, the instructor will have students answer practice questions (open book).
- The practice questions will be corrected and discussed in class.
- On completion, the instructor will administer the test.

Successful completion of each unit test is a requisite to successful completion of Part I. Some students may already have a strong basic knowledge of hoists and their operation. In this case the program monitor may permit the student to omit parts of the Part I program. The monitor may require the student to take only the test instead of reading the text and answering the practice questions.

The Units of Part I will cover these topics:

#### **Components**

Mine Hoist	Clutch	Electrical System (General)
Hydraulic System	Drum/Wheel	*Electrical System (Fundamentals)
Shafts	Wire Rope	Communication System
Conveyance	Safety Controller	Lubrication
Headframes	Depth Indicator	Inspection
Sheaves	Control Panel	Maintenance
Brakes		Safety Features

#### **Procedures**

Beginning of Shift Activities.  
Routine Shift Activities  
End of Shift Activities  
Emergency Procedures.  
Federal Regulations for Hoisting Procedures

\*The Electrical System (Fundamentals) lesson is an advanced lesson. It is to be used where the hoist operator is required by the state or mine to have additional knowledge of Electrical Systems.

## PART II

Part II of the training program is in two units. Objectives of the units are to:

- Enable the student to identify the specific types of components for the hoist that he/she is being trained to operate, and to identify the persons responsible for inspection, lubrication and maintenance of these components.
- Enable the student to locate the hoist components, the inspection, lubrication, and maintenance points, and the operational controls of the hoist and its accessories.

A list of types of hoist components and of persons responsible for maintaining, lubricating and inspecting the components appears on pages 4 and 5. The student will indicate the type of component and the person responsible for its maintenance, lubrication and inspection for the hoist he/she is being trained to operate.

A second list of hoist components, maintenance, lubrication, and inspection points and controls appears on page 6. The student will indicate the location of these components, and the maintenance, lubrication and inspection points.

The program monitor or instructor gives the student the lists to be completed. The specific procedure the student uses may vary but will include the following:

Discussion with the hoist operator on:

- Safety regulations in and around the hoist and its components.
- Location of hoist components and controls.
- Responsibilities of the hoist operator in inspection, lubrication, and maintenance.
- General location of inspection, lubrication, and maintenance points.

Inspection of components to identify the specific type. Since the student will have completed the Part I unit on the component he/she should be able to identify the specific type without assistance. If assistance is needed he/she may consult the hoist operator or the program monitor.

A tour of the hoist area to specifically locate inspection, lubrication, and maintenance points. These points will be indicated on the location list.

The program monitor will review the lists after they have been completed by the student. Assistance may be requested from the hoist operator, maintenance, or engineering personnel.

In addition it is recommended that the student tour the hoist area with an experienced operator and point out the types of components, their controls, and the inspection, lubrication and maintenance points.



## PART II

### HOIST COMPONENT IDENTIFICATION

SLOPE ☐  
 ANGLE \_\_\_\_\_°

SHAFT ☐

DEPTH/LENGTH \_\_\_\_\_ FT.

#### WORKING LEVELS

Single ☐  
 Multi ☐ (\_\_\_\_)

#### CONVEYANCES

Car (Slope) ☐  
 Cage ☐  
 Skip and Cage ☐  
 Elevator ☐  
 Skip Dump ☐  
 Overturn ☐  
 Side Dump ☐  
 Bottom Dump ☐  
 Tail Ropes ☐  
 Counterweight ☐  
 Double Conveyance ☐

#### TYPE HOIST

Drum ☐  
 Drum Grooves  
 Helical ☐  
 Parallel ☐  
 Le Bus ☐  
 Koepe Wheel ☐  
 Single Drum/Wheel ☐  
 Multi Drum/Wheel ☐  
 Ropes  
 Single ☐  
 Multi ☐ (\_\_\_\_)

#### SHAFT GUIDES

Wood ☐  
 Steel Rails ☐  
 Wire Ropes ☐  
 Tracks (Slope) ☐

#### BRAKES

Drum  
 Jaw ☐  
 Parallel Motion ☐  
 Disc ☐

#### CLUTCH

None ☐  
 Single ☐  
 Double ☐  
 Type  
 Friction ☐  
 Tooth ☐

#### DRIVE MOTORS

Alternating Current ☐  
 Direct Current  
 SC Rectifier ☐  
 Motor Generator ☐

#### ELECTRIC BRAKING

DC Drive, Dynamic Braking ☐  
 AC Drive  
 Plugging ☐  
 Dynamic Braking ☐

**COMMUNICATIONS**

Bell System ☐  
Telephone ☐  
Radio ☐  
Public Address ☐  
Flashing Lights ☐  
Meters and Gauges  
Main Power  
Voltmeter ☐  
Ammeter ☐  
Hoist Motor  
Voltmeter ☐  
Ammeter ☐  
Rope Speed Motor ☐

**LUBRICATION**

Oil Flow System ☐  
Sight Glass ☐  
Pressure Gage ☐  
Oil Reservoir System ☐  
Dipstick ☐  
Sight Glass ☐  
Portable Grease Gun ☐  
Automatic Installed System ☐  
Manual Installed System ☐  
Type Oil Used \_\_\_\_\_  
Storage Location \_\_\_\_\_  
Type Grease Used \_\_\_\_\_  
Storage Location \_\_\_\_\_

**HOIST CONTROL**

Production  
Automatic ☐  
Manual ☐  
Service  
Automatic ☐  
Manual ☐

**RESPONSIBILITIES**

Pre-Shift Inspection  
Hoist Operator ☐  
Maintenance ☐  
Other \_\_\_\_\_  
Lubrication  
Hoist Operator ☐  
Maintenance ☐  
Other \_\_\_\_\_  
Preventive Maintenance  
Hoist Operator ☐  
Maintenance ☐  
Other \_\_\_\_\_  
Corrective Maintenance  
Hoist Operator ☐  
Maintenance ☐  
Other \_\_\_\_\_  
Wire Rope Inspection  
Hoist Operator ☐  
Maintenance ☐  
Other \_\_\_\_\_

**SAFETY DEVICES**

Overtravel Cut-out  
Upper Limit Switch ☐  
Lower Limit Switch ☐  
Overspeed Cut-out ☐  
Deadman Switch ☐  
Low Voltage Cut-out ☐

**PART II**  
**LOCATION LIST**

**Log Book**

**Individual Controls**

- Hoist Motor Control
- Brake
  - Dynamic
  - Mechanical
- Clutch
- Hydraulic System
- Lubricating System
- Bypass Switches
- Main Power Switch
- Auxiliary Power Switch
- Deadman Switch

**Gauges and Instruments**

- Oil Gauge
- Voltmeter
- Ammeter
- Rope Speed Motor
- Indicator Lights
- Trouble Lights

**Lubrication Points**

- Hoist Motor Bearings
- Drive Gears
- Drum/Wheel Bearings
- Brakes
  - Linkage and Drawbar Joints
  - Operating Control
  - Hydraulic Motor Bearings
- Clutch
  - Spider Linkage
  - Operating Control

**Conveyance**

- Safety Latch
- Bottom/Side Dump Plate
- Dump Roller
- Safety Dog Mechanism
- Guide Shoes

**Shaft Rope**

- Rollers (Slope)
- Guides
- Safety Gates

**Headframe and Sheaves**

- Slack Rope Cutout Mechanism
- Sheave Bearings
- Wire Rope

**Inspection Points**

**Foundations**

- Motors
- Drum/Wheel
- Brake Mechanism
- Switch Board
- Power Supply
- Hydraulic System
- Lubrication System
- Control Panel
  - Control Levers
- Idler Sheaves
- Headframe and Sheave
- Safety Gates
- Shaft Guides

**Structures**

- Motor Frame
- Hoist Frame
- Headframe
- Brake Linkage
- Clutch Linkage
- Wire Rope
- Sheaves
- Conveyance
- Shaft Guides
- Drive Gears
- Control Levers
- Power Supply

### PART III

In Part III the student will acquire the skills to operate the hoist safely and efficiently under all conditions, to include:

- Beginning of shift activities
- Lowering persons and equipment into the mine
- Moving the conveyance from one level to another
- Hoisting ore and waste from the mine
- End of shift activities
- Emergency and evacuation procedures
- Logging

He/she will be assigned to an experienced hoist operator for this training. The student will have successfully completed training when so certified by the experienced operator.

## INSTRUCTIONS FOR THE STUDENT

The objective of this training program is to give you the knowledges and skills that you need to be certified as a mine hoist operator. The program is in three parts:

- In Part I you will learn the basic components and operations of a mine hoist.
- In Part II you will learn the specific components of the hoist that you are being trained to operate.
- In Part III you will become skilled in operating your assigned hoist.

### PART I

Part I contains 24 units. Each unit describes:

- A basic component or system of a mine hoist, or
- A set of operating procedures

Each unit in Part I is a manual that contains the following:

- A title page stating the title of the unit, the training objective (what the student is expected to know on completing the unit), and the time in hours to complete the unit.
- A list of the instructional objectives (the specific knowledge needed to attain the training objective and the level of proficiency required).
- The instructional material which describes the component, systems or procedures.
- Federal regulations that apply to the unit's subject matter.
- Practice questions that will improve your learning.
- Answers to the practice questions so that you can evaluate your own performance.

Part I is designed to be a self-instruction program. However, if there are enough students it may be conducted as a classroom program.

#### For Self-Instruction

Read the text.

Try to answer the practice questions without using your manual.

Check your answers.

Using the text part of the manual, find the correct answers for those you missed.

Show the completed practice questions to the program monitor.

The program monitor will review your work and if satisfactory will require you to take the test. You may not use the manual for the test.

When you complete the test, give it to the program monitor and have it corrected. You should answer 80% of the test questions correctly.

If your answers are all correct, the program monitor may have you proceed to the next Part I unit or to a related Part II or III unit.

### **For Classroom Instruction**

The Instructor will cover the material in the manual by lecture and discussion.

You will be required to answer the practice questions correctly.

You will then be given the test, to be corrected by the Instructor.

## **PART II**

In Part II you will learn:

- The specific type of each component of the hoist you are being trained to operate.
- The persons responsible for inspection, lubrication and maintenance of each component.
- The location of controls, lubrication, maintenance and inspection points of the hoist components.

The program monitor or instructor will give you two lists and direct you to report to the hoist operator to conduct Part II.

Your first step in Part II will be to discuss with the hoist operator:

- Safety regulations in and around the hoist and its components.
- Location of hoist components and controls.
- Responsibilities of the hoist operator in inspection, lubrication, and maintenance.
- General location of inspection, lubrication, and maintenance points.

You will then inspect all components to identify the specific type. Since you will have completed the Part I unit on the component you should be able to identify the specific type without assistance. If assistance is needed, consult the hoist operator on the program monitor. You will indicate the specific type of component and the persons responsible for lubrication, inspection, and maintenance on one of the lists.

You will then tour the hoist area to specifically locate inspection, lubrication, and maintenance points. These points will be indicated on the location list.

The program monitor will review the lists after you have completed them.

The program monitor may require you to tour the hoist area with an experienced operator and point out the types of components, their controls, and the inspection, lubrication and maintenance points.

### PART III

In Part III you will acquire the skills to operate the hoist safely and efficiently under all conditions, to include:

- Beginning of shift activities
- Lowering persons and equipment into the mine
- Moving the conveyance from one level to another
- Hoisting ore and waste from the mine
- End of shift activities
- Emergency and evacuation procedures
- Logging

You will be assigned to an experienced hoist operator for this training. You will have successfully completed training when so certified by the experienced operator.

The attached check-off list shows the specific skills you will need to acquire in Part III. The hoist operator assigned to instruct you will check off each of the skills that you acquire. He will fill in the blanks in the last paragraph and sign the list when all the skills have been checked off.

### Part III

#### Mine Hoist Operator Check List—Beginning of Shift Activities

- \_\_\_\_\_ Find out general condition of the hoist
- \_\_\_\_\_ Assure that the hoist is properly lubricated
- \_\_\_\_\_ Assure that power is available to the hoist
- \_\_\_\_\_ Run an empty conveyance the full length of the shaft
- \_\_\_\_\_ Test the overspeed cutout switch
- \_\_\_\_\_ Test the overtravel cutout switches
- \_\_\_\_\_ Test the slack rope switch
- \_\_\_\_\_ Test the deadman switch
- \_\_\_\_\_ Log information
- \_\_\_\_\_ Examine conveyance safety dogs

#### Mine Hoist Operator Check List—Routine Shift Activities

- \_\_\_\_\_ Move the conveyance
  - \_\_\_\_\_ Signal with communication systems
  - \_\_\_\_\_ Start the conveyance moving
  - \_\_\_\_\_ Accelerate to cruising speed
  - \_\_\_\_\_ Cruise
  - \_\_\_\_\_ Decelerate
  - \_\_\_\_\_ Stop the conveyance
- \_\_\_\_\_ Raise ore or waste

#### Mine Hoist Operator Check List—End of Shift Activities

- \_\_\_\_\_ Place conveyance clear of landings, preferably with rope slack
- \_\_\_\_\_ Secure conveyance
- \_\_\_\_\_ Log information

#### Mine Hoist Operator Check List—Emergency Procedures

- \_\_\_\_\_ Restore low power
- \_\_\_\_\_ Return conveyance to operating area after overtravel
- \_\_\_\_\_ Restore power after overspeed
- \_\_\_\_\_ Restore air pressure on braking system

This is to certify that \_\_\_\_\_ has demonstrated to me that he/she has the skills and knowledges required to operate the \_\_\_\_\_ mine hoist at \_\_\_\_\_ Mine.

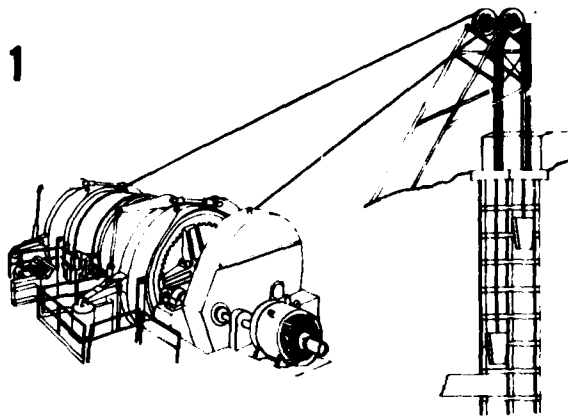
\_\_\_\_\_  
Hoist Operator Instructor



# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 1

### MINE HOIST



## OBJECTIVE

The trainee will know the major components  
for the hoist

## TIME

1

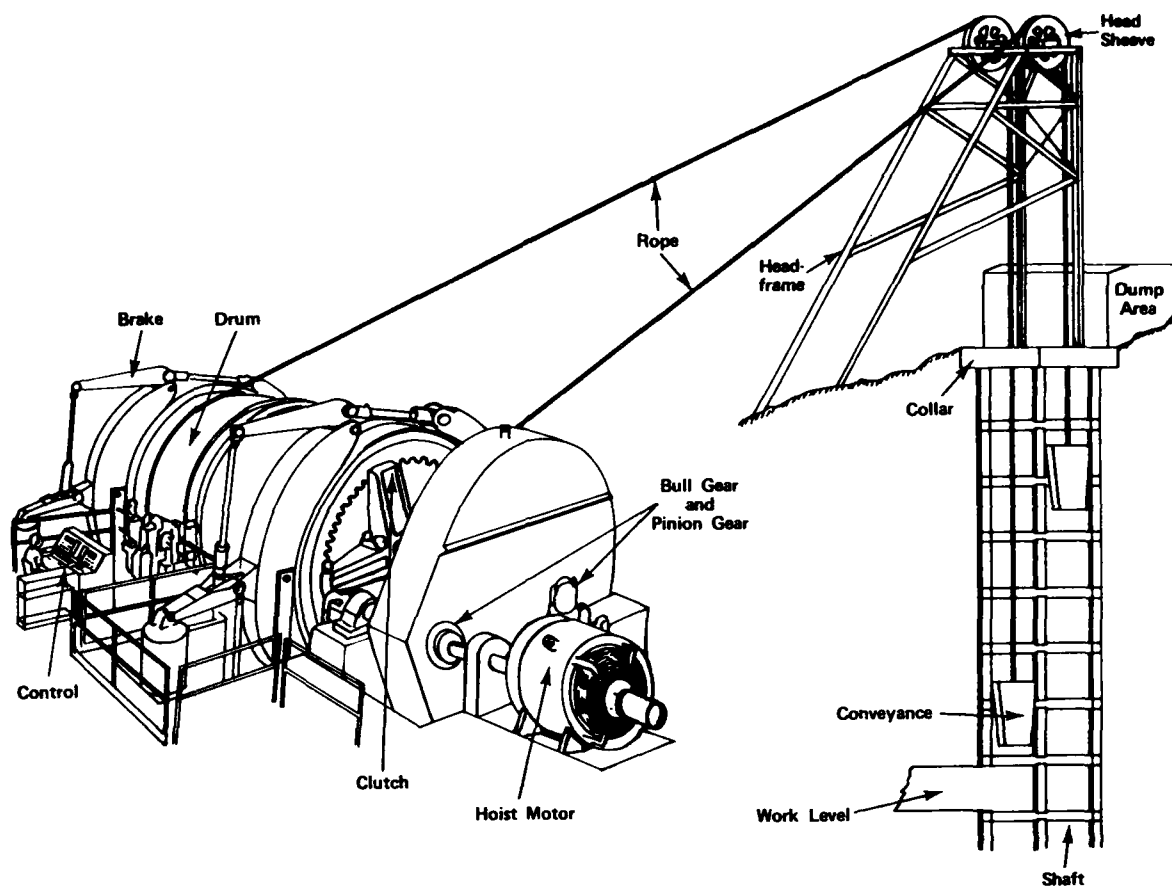
## **INSTRUCTIONAL OBJECTIVES FOR THE MINE HOIST**

The trainee will be able to write in one or two sentences the function (use) of the mine hoist.

The trainee will be able to identify the parts of the mine hoist.

Given an illustration of a mine hoist where each of the parts is labeled with a letter the trainee will be able to:

1. write the name of each labeled part;
2. match each lettered part to a sentence that explains it.



The MINE HOIST lowers men and materials into the mine and raises men, materials, ore and waste out of the mine.

The principal parts of the hoist are:

- MINE SHAFT—the path from the surface to the underground workings;
- COLLAR—the area surrounding the surface opening of the shaft;
- DUMP AREA—the area where ore and waste are deposited;
- WORK LEVEL—the mine level from which ore or waste is being hoisted;
- CONVEYANCE—the platform on which men, materials, ore and waste are hoisted/lowered;
- HEADFRAME—the structure which holds the head sheave;
- HEAD SHEAVE—the grooved wheel which supports the rope;
- HOIST ROPE—the wire cable which raises and lowers the conveyance;
- HOIST DRUM or WHEEL—the drum or wheel which raises and lowers the hoist rope;
- HOIST MOTOR—the motor which turns the hoist drum or wheel;
- PINION and BULL GEARS—gears which connect the hoist motor to the hoist drum or the hoist wheel;
- CLUTCH—the device which engages or disengages the drum from the hoist motor;
- BRAKE—the device which slows, stops and holds the hoist rope;
- CONTROL—the station from which the hoist is operated.

### PRACTICE QUESTIONS FOR THE MINE HOIST

1. What is a mine hoist used for? \_\_\_\_\_  
\_\_\_\_\_
2. Write a brief definition of each of the following terms:
  - a. hoist motor - \_\_\_\_\_  
\_\_\_\_\_
  - b. control - \_\_\_\_\_  
\_\_\_\_\_
  - c. collar - \_\_\_\_\_  
\_\_\_\_\_
  - d. hoist rope - \_\_\_\_\_  
\_\_\_\_\_
  - e. mine shaft - \_\_\_\_\_  
\_\_\_\_\_
  - f. brake - \_\_\_\_\_  
\_\_\_\_\_
  - g. work level - \_\_\_\_\_  
\_\_\_\_\_
  - h. conveyance - \_\_\_\_\_  
\_\_\_\_\_

i. hoist drum or wheel - \_\_\_\_\_

j. headframe - \_\_\_\_\_  
\_\_\_\_\_

k. head sheave - \_\_\_\_\_  
\_\_\_\_\_

l. pinion and bull gears - \_\_\_\_\_  
\_\_\_\_\_

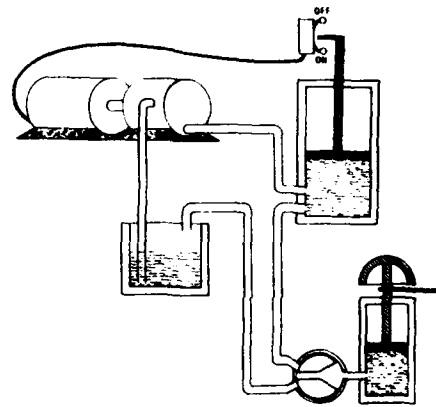
## ANSWERS TO MINE HOIST PRACTICE QUESTIONS

1. lowers men and materials into the mine, and raises men, materials, and ore, waste out of the mine.
2.
  - a. motor which turns hoist drum or wheel
  - b. station from which the hoist is operated
  - c. area surrounding the surface opening of the shaft
  - d. wire cable which raises and lowers the conveyance
  - e. path from surface to underground workings
  - f. device which slows, stops, and holds the hoist rope
  - g. mine level from which ore or waste is being hoisted
  - h. platform on which men, materials, ore, and waste are hoisted/lowered
  - i. the drum or wheel which raises and lowers the hoist rope
  - j. structure which holds the head sheave
  - k. grooved wheel which supports the hoist rope
  - l. gears which connect the hoist motor to the hoist drum or wheel

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 2

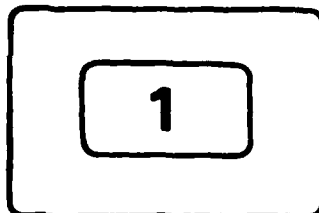
# HYDRAULIC SYSTEM



## OBJECTIVE

The trainee will know the operating principles and major components of the hydraulic system

## TIME



## **INSTRUCTIONAL OBJECTIVES FOR THE HYDRAULIC SYSTEM**

The trainee will be able to state in one or two sentences the function (use) of the hydraulic system.

The trainee will be able to identify the parts of the hydraulic system.

Given an illustration of the hydraulic system where each part is labeled with a letter, the trainee will be able to:

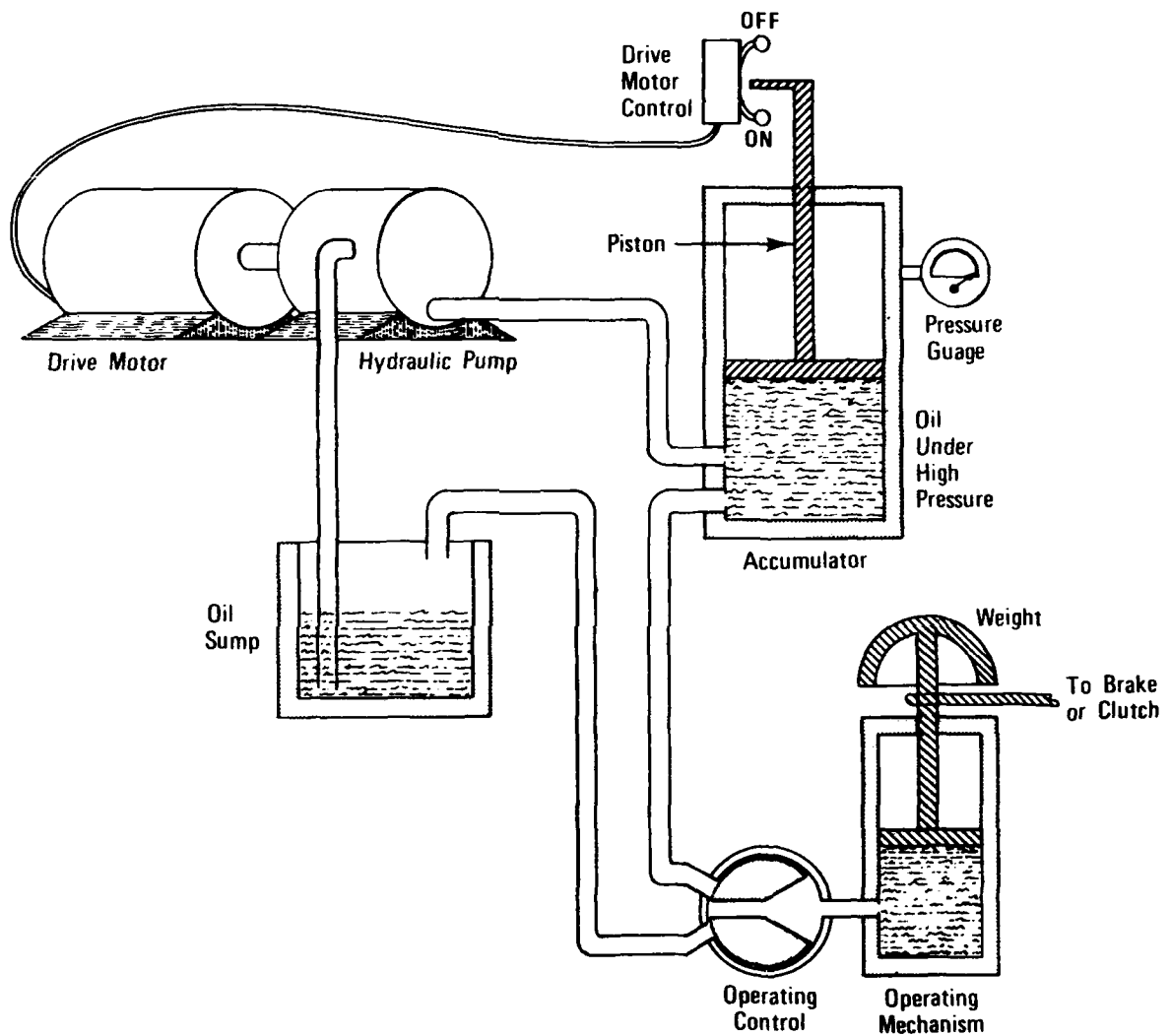
1. write the name of each labeled part;
2. match each lettered part to a sentence that explains it.

The trainee will be able to explain the operating principles of the hydraulic system.

Given a passage explaining how the hydraulic system works, where some of the steps have blanks, the trainee will be able to fill in these blanks.



A Hydraulic System enables the hoist operator to apply or release the hoist brakes and to engage or disengage the clutch. These operations can be performed from a remote station with little effort from the operator. Controls cause oil under high pressure to force a piston or other mechanism to move and perform the desired work.



A basic hydraulic system consists of these parts:

- A hydraulic Pump that will pressurize oil.
- An electric Drive Motor that operates the pump.
- A Drive Motor Control that will start and stop the drive motor.

- An Accumulator that will store oil at high pressure. The accumulator is usually a cylinder and piston. Oil at high pressure is stored beneath the piston. The space above the piston may be filled with pressurized air to force the piston downward against the oil. Sometimes coiled springs or weights instead of high pressure air are used to force the piston against the oil.
- An Operating Control which the operator uses to control the flow of oil in the system.
- A Sump that stores oil at low pressure.
- An Operating Mechanism, usually a cylinder and piston, that does the work. This mechanism may apply or release the brake, or engage or disengage the clutch. If oil flows from the accumulator to the operating mechanism, the piston moves upward, lifts the weight and moves levers in one direction. If the oil flows from the operating mechanism to the sump, the piston moves downward because of the weight, and the levers move in the opposite direction.

The system works as follows:

- Using the operating control, the operator allows oil to flow from the accumulator into the operating mechanism.
- The piston moves upward and may, for example, engage the clutch.
- When the operator wants to disengage the clutch, he/she again uses the operating control. Oil is allowed to flow from the operating mechanism to the sump.
- The piston in the operating mechanism will move downward because of the weight.
- As oil flows out of the accumulator, the accumulator piston moves downward. This movement causes the drive motor control to start the drive motor.
- The drive motor operates the pump which pumps oil from the sump to the accumulator.
- This increase in oil raises the accumulator piston.
- When sufficient oil has been pumped, the upward movement of the accumulator piston shuts off the drive motor.

## PRACTICE QUESTIONS FOR THE HYDRAULIC SYSTEM

1. A hydraulic system enables the hoist operator to apply or release the hoist \_\_\_\_\_ and to engage or disengage the \_\_\_\_\_.
2. Write a brief explanation of how each part works.
  - a. pump - \_\_\_\_\_
  - b. drive motor - \_\_\_\_\_
  - c. drive motor control - \_\_\_\_\_
  - d. accumulator - \_\_\_\_\_
  - e. operating control - \_\_\_\_\_
  - f. sump - \_\_\_\_\_
  - g. operating mechanism - \_\_\_\_\_
3. The hydraulic system works as follows:
  - The operator allows oil to flow \_\_\_\_\_.
  - The piston moves upward and may \_\_\_\_\_.
  - When the clutch is to be disengaged, oil is allowed to flow from \_\_\_\_\_.
  - The piston will move \_\_\_\_\_.
  - As oil flows out of the accumulator, the accumulator piston moves \_\_\_\_\_.
  - This movement causes the drive motor control to \_\_\_\_\_.
  - The motor operates the pump which pumps \_\_\_\_\_.
  - This increase in oil raises \_\_\_\_\_.
  - When enough oil has been pumped, the upward movement of the accumulator piston \_\_\_\_\_.

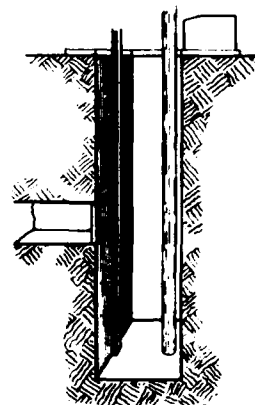
## ANSWERS TO PRACTICE QUESTIONS

1. brakes; clutch
2.
  - a. pressurizes oil
  - b. operates a pump
  - c. starts and stops the drive motor
  - d. stores oil at high pressure
  - e. used to control the flow of oil in the system
  - f. stores oil at low pressure
  - g. applies or releases the brake and engages or disengages the clutch
3.
  - from the accumulator into the operating mechanism.
  - engage the clutch.
  - the operating mechanism to the sump.
  - downward.
  - downward.
  - start the drive motor.
  - oil from the sump to the accumulator.
  - the accumulator piston.
  - shuts off the pump drive motor.

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 3

# SHAFT



## OBJECTIVE

The trainee will know the major components  
and federal regulations for the shaft

## TIME

1/2

## INSTRUCTIONAL OBJECTIVES FOR THE SHAFT

The trainee will be able to answer multiple-choice questions concerning the function (use) of shafts.

The trainee will be able to identify the parts of a shaft.

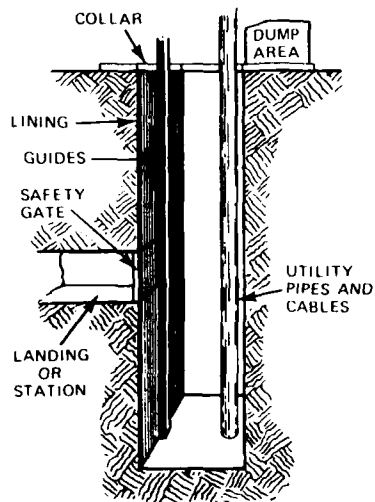
Given an illustration of a shaft where each of the parts is labeled with a letter, the trainee will be able to:

1. write the name of each labeled part;
2. match each lettered part to a sentence that explains it.

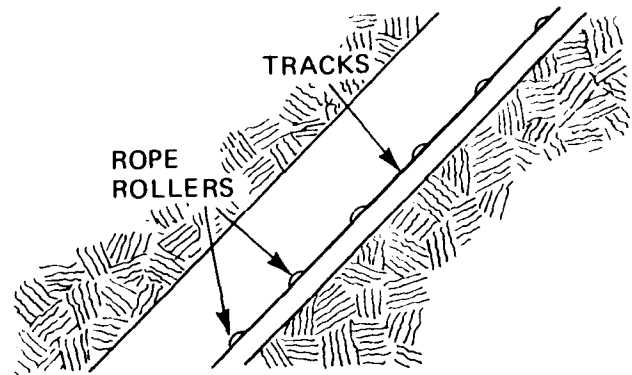
The trainee will be able to answer multiple-choice questions concerning the application of federal regulations for shafts.

The Shaft provides a path for one or more conveyance, power cables, and communication and other control links. There are two types of shafts: vertical and slope.

### VERTICAL SHAFT

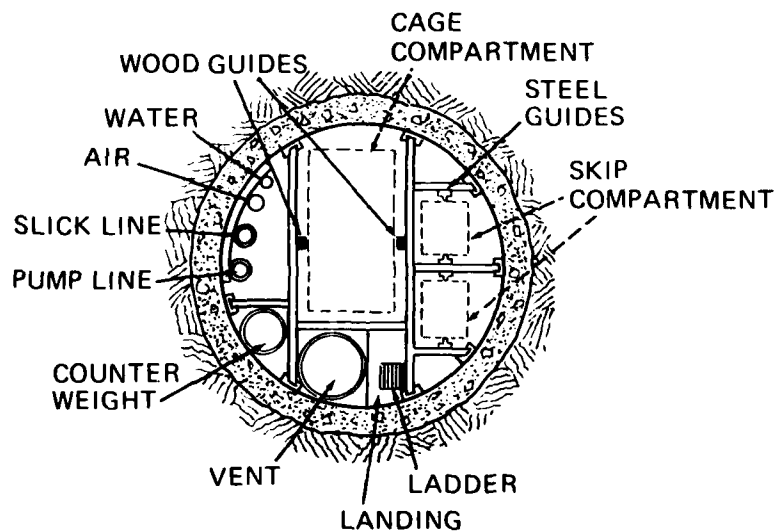


### SLOPE SHAFT



A shaft may be divided into Compartments. Each compartment provides a path for a conveyance, counter weight, cables or other mine equipment.

### ONE TYPE OF VERTICAL SHAFT



The Collar is the area surrounding the shaft opening at the face of the mine.

The Shaft Lining is the sides of the shaft. It is made of timber, steel or cement.

Shaft Guides keep the conveyance in proper position. Vertical shafts have fixed guides made of wood timbers or steel rails or rope guides of locked coil ropes. Slope shafts have tracks to guide the conveyance and rollers to guide the rope.

A Landing or Station is the opening of a level onto the shaft.

A Safety Gate is the guard across a landing of the shaft.

The Dump is the area where the conveyance empties its load of coal or ore.

Utility Pipes and Cables are the paths for power, water, air and communications. They enter the mine through the shaft.

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic Mines**

#### **SHAFTS**

57.19-100 *Mandatory*. Shaft landings shall be equipped with substantial safety gates so constructed that material will not go through or under them; gates shall be closed except when loading or unloading shaft conveyances.

57.19-101 *Mandatory*. Positive stopblocks or a derail switch shall be installed on all tracks leading to a shaft collar or landing.

57.19-104 *Mandatory*. Suitable clearance at shaft stations shall be provided to allow safe movement of persons, equipment and materials.

57.19-105 *Mandatory*. A safe means of passage around open shaft compartments shall be provided on landings with more than one entrance to the shaft.

57.19-106 *Mandatory*. Shaft sets shall be kept in good repair and clean of hazardous material.

57.19-107 *Mandatory*. Hoistmen shall be informed when men are working in a compartment affected by that hoisting operation and "Men Working in Shaft" sign shall be posted at the hoist.

57.19-108 *Mandatory*. When men are working in a shaft "Men Working in Shaft" signs shall be posted at all devices controlling hoisting operations that may endanger such men.

57.19-109 *Mandatory*. Shaft inspection and repair work in vertical shafts shall be performed from substantial platforms equipped with bonnets or equivalent overhead protection.

57.19-133 *Mandatory*. Shafts that have not been inspected within the past 7 days shall not be used until an inspection has been conducted by a competent person.



57.19-135 *Mandatory*. Rollers used in operating inclined shafts shall be lubricated, properly aligned and kept in good repair.

#### **Coal Mines**

##### **75.1400-3 DAILY EXAMINATION OF HOISTING EQUIPMENT**

The daily examination required by 75.1400, of hoisting equipment, including automatic elevators shall include but not be limited to the following: An observation of the lining and all other equipment and appurtenances installed in the shaft.

##### **75.1403-11 CRITERIA-ENTRANCES TO SHAFTS AND SLOPES**

All open entrances to shafts shall be equipped with safety gates at the top and at each landing. Such gates shall be self-closing and shall be kept closed except when the cage is at such landing.

## PRACTICE QUESTIONS FOR SHAFT

Complete this sentence with the correct answer:

1. The shaft in a mine provides \_\_\_\_\_.
2. Write a brief definition of each of the following terms:
  - a. collar - \_\_\_\_\_
  - b. lining - \_\_\_\_\_
  - c. dump - \_\_\_\_\_
  - d. safety gate - \_\_\_\_\_
  - e. guides - \_\_\_\_\_
  - f. landing/station - \_\_\_\_\_
  - g. utility pipes and cables - \_\_\_\_\_

Complete these sentences with the correct answers.

### Metal and Nonmetallic Mines

3. Shaft landings shall be equipped with substantial \_\_\_\_\_ so constructed that materials will not go through or under them.
4. Gates shall be \_\_\_\_\_ except when loading or unloading shaft conveyances.
5. Suitable clearance at shaft stations shall be provided to allow \_\_\_\_\_.
6. Shaft sets shall be kept in good repair and clean of \_\_\_\_\_.
7. Hoistmen shall be informed when men are working in a compartment affected by that hoisting operation and "Men Working in Shaft" sign shall be \_\_\_\_\_.
8. When men are working in a shaft \_\_\_\_\_ signs shall be posted at all devices controlling hoisting operations that may endanger such men.
9. Shafts that have not been inspected within the past 7 days shall not be used until \_\_\_\_\_.
10. \_\_\_\_\_ used in operating inclined shafts shall be lubricated, properly aligned and kept in good repair.
11. \_\_\_\_\_ or a \_\_\_\_\_ shall be installed on all tracks leading to a shaft collar or landing.

**Coal Mines**

12. The shaft lining and components shall be examined \_\_\_\_\_ .
13. All open entrances to shafts shall be equipped with \_\_\_\_\_ at the top and at each landing.
14. Safety gates shall be self-closing and shall be kept \_\_\_\_\_ except when the cage is at such landing.

## ANSWERS TO PRACTICE QUESTIONS FOR SHAFT

1. a path for one or more conveyances, power cables, and communication and other control links.
2.
  - a. collar - area surrounding shaft opening at the face of the mine.
  - b. lining - sides of the shaft.
  - c. dump - area where conveyance empties its load of coal or ore.
  - d. safety gate - the guard across a landing of the shaft.
  - e. guides - devices to keep the conveyance in proper position.
  - f. landing/station - the opening of a level onto the shaft.
  - g. utility pipes and cables - paths for power, water, air and communications.
3. safety gates
4. closed
5. safe movement of persons, equipment and materials.
6. hazardous material.
7. posted at the hoist.
8. "Men Working in Shaft"
9. an inspection has been conducted by a competent person.
10. Rollers
11. Positive stopblocks; derail switch
12. daily
13. safety gates
14. closed

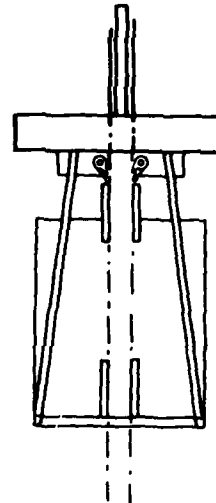
# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 4

# CONVEYANCES

## OBJECTIVE

The trainee will know the major components and federal regulations for the conveyance.



## TIME

1/2

## INSTRUCTIONAL OBJECTIVES FOR CONVEYANCES

The trainee will be able to answer in writing multiple-choice questions about the functions (uses) of the different conveyances.

The trainee will be able to identify the types of conveyances. Given illustrations of the different types of conveyance, the trainee will be able to write skip, cage, or car for each conveyance.

The trainee will be able to identify in writing the parts of a skip and a cage:

1. Given illustrations of a skip and a cage, where each part is labeled with a letter, the trainee will be able to write the name of each lettered part.
2. The trainee will be able to answer in writing multiple-choice questions about the functions (uses) of the conveyance parts.

The trainee will be able to answer in writing multiple-choice questions concerning the federal regulations for the conveyance.

## CONVEYANCES

A conveyance is a platform that carries men and equipment to the working levels of the mine, and carries men, equipment, and ore and muck to the surface.

In a shaft mine there are two basic kinds of conveyance:

- cage — to carry men and equipment
- skip — to carry ore, waste, and some heavy equipment.

The parts of a cage are: (See Figure 1)

The man compartment is the protected enclosure that the men ride in.

The bonnet protects the man compartment from falling objects.

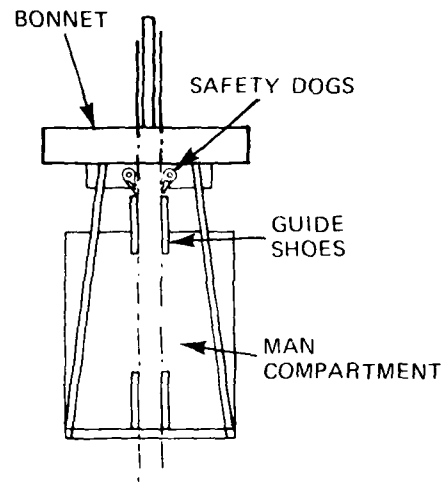


Figure 1

The safety dog (catch) is an emergency braking device that is attached to the conveyance. A typical safety dog is shown in Figure 2.

The safety dog is activated by a spring if slack appears in the hoist rope. When activated, the safety dog digs into the shaft guides, bringing the conveyance to a stop.

The guide shoe is the part of the conveyance that travels along the shaft guide. The guide shoe prevents the conveyance from moving horizontally in the shaft.

A skip is designed to dump its contents by:

- turning upside down, or
- opening its bottom or lower side.

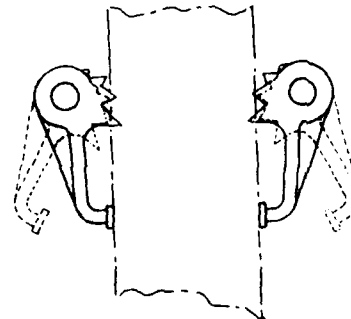


Figure 2

The parts of an upside-down dumping skip are: (See Figure 3)

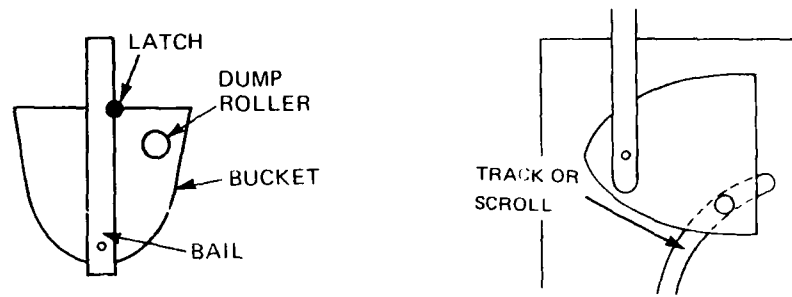


Figure 3

The dump roller is a wheel or roller mounted on the side of the conveyance.

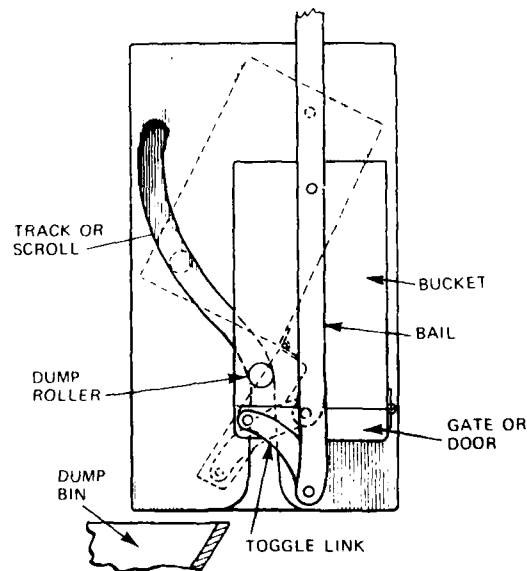
The bail is the framework that supports the skip.

The bucket is the container for the ore, waste or heavy equipment.

The latch holds the skip upright.

The track or scroll engages the dump roller and dumps the skip.

A skip that dumps its contents by opening its bottom or lower side is called a bottom-dump skip. The parts of a bottom-dump skip are: (See Figure 4)



The gate or door is the side or bottom that opens to let ore out.

The actuating mechanism is the linkage that causes the gate to open. It includes the dump roller, and the track or scroll.

The bail is the framework that supports the skip.

The bucket is the container for the ore, waste and heavy equipment.



The safety latch is the device which prevents the gate from opening accidentally. It is actuated by the toggle link as the dump roller enters the scroll.

As the skip nears the dump point, the dump roller follows along a track or scroll. The shape of the track or scroll causes the roller to move horizontally and turn the skip upside down or open the skip dump gates.

Some conveyances are combinations of a skip and a cage. These combinations may look like: (See Figure 5)

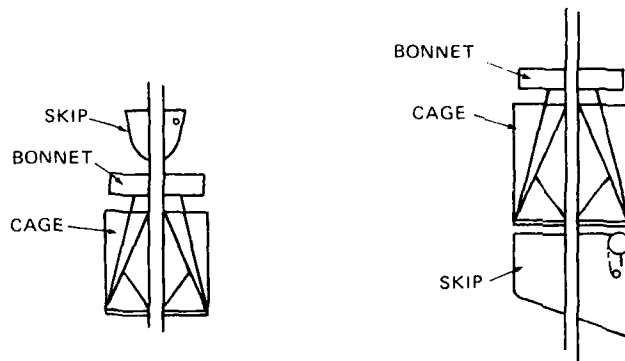
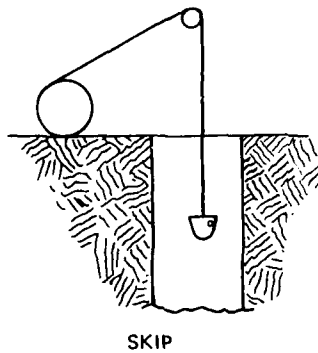


Figure 5

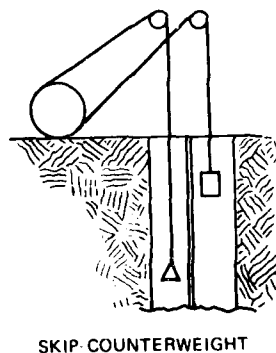
A vertical shaft hoist may have:

- a single rope and single conveyance. (See Figure 6)
- two ropes with a conveyance and a counterweight. (See Figure 7)
- two ropes with two conveyances. (See Figure 8)



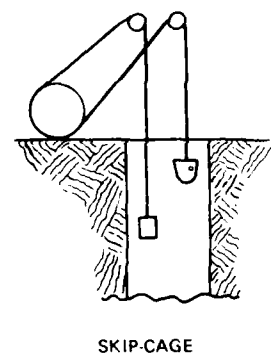
SKIP

Figure 6



SKIP-COUNTERWEIGHT

Figure 7



SKIP-CAGE

Figure 8

A tailrope may be connected to the bottom of the conveyances or conveyance and counterweight to balance the weight of the hoist rope. (See Figure 9)

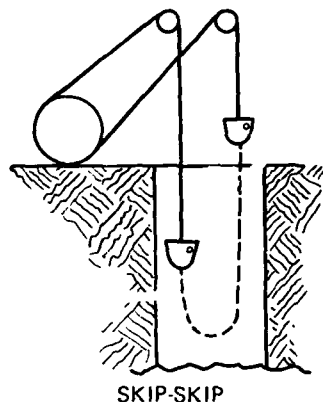


Figure 9

In a slope mine there are also two basic kinds of conveyance:

- man cars—to carry men and equipment. Man cars are fitted with seats.
- ore cars—to carry ore, waste, and some heavy equipment. Ore cars can be dumped by turning them upside down or by opening the bottom. (See Figure 10)



Figure 10

Safety dogs are provided to stop the car if the rope breaks or goes slack. The dogs are forced into the ground by a spring. Magnetic brake cars may also be used to stop the man car if the rope breaks. They are down slope from the man car and apply brakes through magnets.

#### FEDERAL REGULATIONS (From Title 30 CFR)

##### Metal and Nonmetallic Mines

57.19-45 *Mandatory*. Man cages and skips used for hoisting or lowering employees or other persons in any vertical shaft or any incline shaft with an angle of inclination of forty-five (45) degrees from the horizontal shall be covered with a metal bonnet.

57.19-49 *Mandatory*. Buckets shall not be used to hoist men except during shaft sinking operations, inspection, maintenance, and repairs.

57.19-50 *Mandatory.* Buckets used to hoist persons during vertical shaft sinking operations shall:

- (a) Be securely attached to a crosshead when traveling in either direction between the lower and upper crosshead parking locations.
- (b) Have overhead protection when the shaft depth exceeds 50 feet.
- (c) Have sufficient depth or a suitably designed platform to transport persons safely in a standing position.
- (d) Have devices to prevent accidental dumping where the bucket is supported by a bail attached to its lower half.

#### **Coal Mines**

75.1403-3(d) Cages used for hoisting men shall be constructed with the sides enclosed to a height of at least 6 feet and should have gates, safety chains, or bars across the ends of the cage when men are being hoisted or lowered.

75.1403-3(e) Self dumping cages, platforms, or other devices used for transportation of men shall have a locking device to prevent tilting when men are transported thereon.

## PRACTICE QUESTIONS FOR CONVEYANCES

Complete these sentences with the correct answers:

1. The two basic types of conveyance are a \_\_\_\_\_ and a \_\_\_\_\_.
2. A \_\_\_\_\_ is used mainly to carry ore, waste, and some heavy equipment from the mine.
3. A \_\_\_\_\_ is used mainly to carry men and equipment.
4. The protective enclosure that men ride in is the \_\_\_\_\_.
5. The man compartment is protected from falling objects by a \_\_\_\_\_.
6. The \_\_\_\_\_ is an emergency braking device attached to the conveyance.
7. The part of the conveyance that travels along the shaft guide is the \_\_\_\_\_.
8. A skip dumps its contents in two ways:
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
9. An upside-down dumping skip has a dump roller, which is a \_\_\_\_\_, a bail, which is \_\_\_\_\_, and a latch, which \_\_\_\_\_.
10. The parts of a bottom-dump skip are:
  - a. Gate or door—the side or bottom that \_\_\_\_\_.
  - b. Actuating mechanism—the linkage that \_\_\_\_\_.  
It includes \_\_\_\_\_.
  - c. Safety latch—the device which prevents \_\_\_\_\_.
11. As the skip nears the dump point, the dump roller follows along a \_\_\_\_\_. The shape of the \_\_\_\_\_ causes the roller \_\_\_\_\_ and turn the skip upside down or \_\_\_\_\_.
12. A vertical shaft hoist may have:
  - a. A single rope and a \_\_\_\_\_
  - b. Two ropes with a conveyance and a \_\_\_\_\_
  - c. Two ropes with two \_\_\_\_\_
13. A \_\_\_\_\_ may be connected to the bottom of the conveyances to balance the weight of the hoist rope.

14. In a slope mine the two basic kinds of conveyances are:

a. \_\_\_\_\_

b. \_\_\_\_\_

15. Man cars in a slope mine may be stopped by \_\_\_\_\_ or \_\_\_\_\_ if the rope breaks.

#### **Metal and Nonmetallic Mines**

16. Man cages and skips used for transporting people in any vertical shaft or any slope shaft with a  $45^\circ$  inclination angle from the horizontal shall be covered with \_\_\_\_\_.

17. Buckets shall not be used to \_\_\_\_\_ except during shaft sinking operations, maintenance, inspection, and repairs.

#### **Coal Mines**

18. Cages used for hoisting men shall be constructed with the sides \_\_\_\_\_ and shall have \_\_\_\_\_ across the ends of the cage where people are being hoisted or lowered.

19. Self-dumping cages, platforms, or other devices used for transportation of men shall have a \_\_\_\_\_ when men are transported in them.

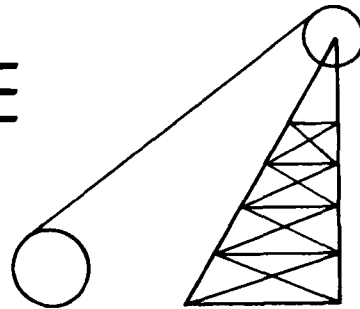
## ANSWERS TO PRACTICE QUESTIONS FOR CONVEYANCES

1. skip; cage
2. skip
3. cage
4. man compartment
5. bonnet
6. safety dog
7. guide shoe
8. a. by turning upside down  
b. by opening its bottom or lower side
9. wheel or roller mounted on side of conveyance; framework supporting the skip; holds the skip upright.
10. a. opens to let ore out  
b. causes the gate to open; dump roller, toggle link and track or scroll.  
c. the gate from opening accidentally
11. track or scroll; track or scroll; to move horizontally; open the skip dump gates.
12. a. single conveyance  
b. counterweight  
c. conveyances
13. tailrope
14. a. man cars  
b. ore cars
15. magnetic cars or safety dogs
16. a metal bonnet
17. hoist men
18. enclosed to a height of at least six feet; gates, safety chains, or bars
19. locking device to prevent tilting

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 5

### HEADFRAME



#### OBJECTIVE

The trainee will know the major components  
and federal regulations for the headframe

#### TIME

1/2

## **INSTRUCTIONAL OBJECTIVES FOR THE HEADFRAME**

The trainee will be able to state in one or two sentences the function (use) of headframes.

The trainee will be able to identify a headframe and related mine parts.

Given an illustration of a slope or vertical shaft in operation where each part is labeled with a letter, the trainee will be able to write the name of each lettered part.

The trainee will be able to describe fleet angle.

The trainee will be able to answer multiple-choice questions concerning the:

1. definition of fleet angle;
2. correct fleet angle;
3. result of an incorrect fleet angle.

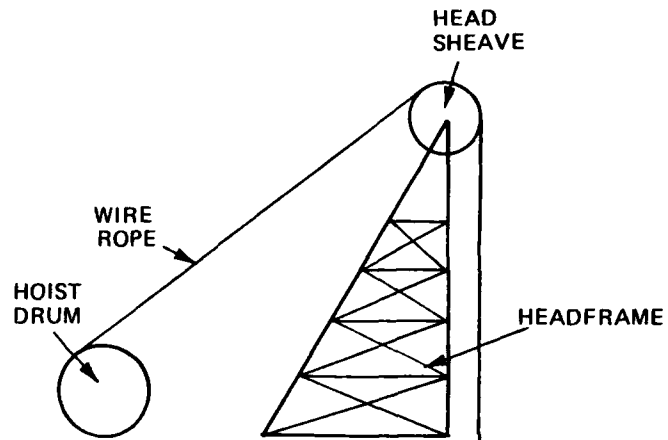
The trainee will be able to answer multiple-choice questions concerning the federal regulations for headframes.



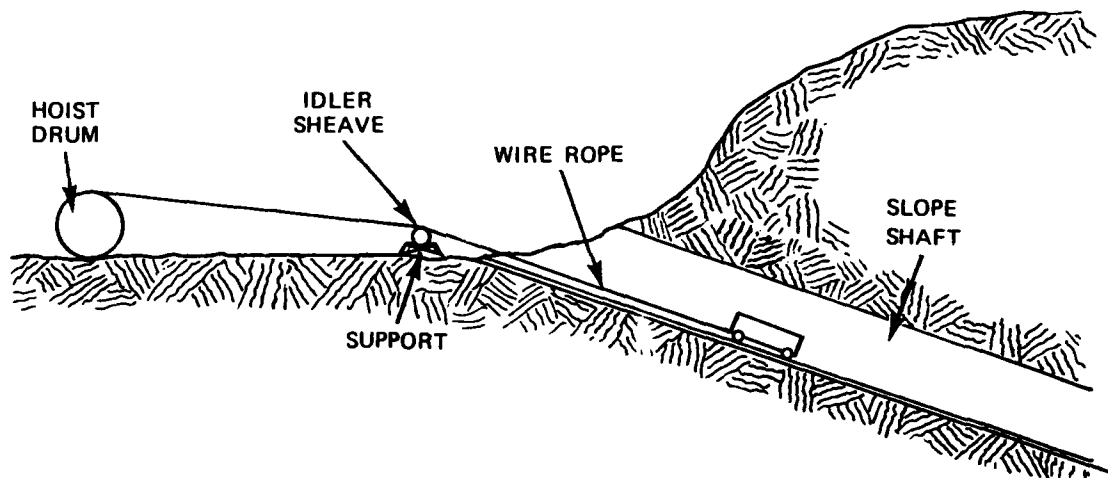
The Headframe supports the headsheave or head (Koepe) wheel over a shaft.

The headframe for a drum hoist holds a headsheave which supports the hoist rope.

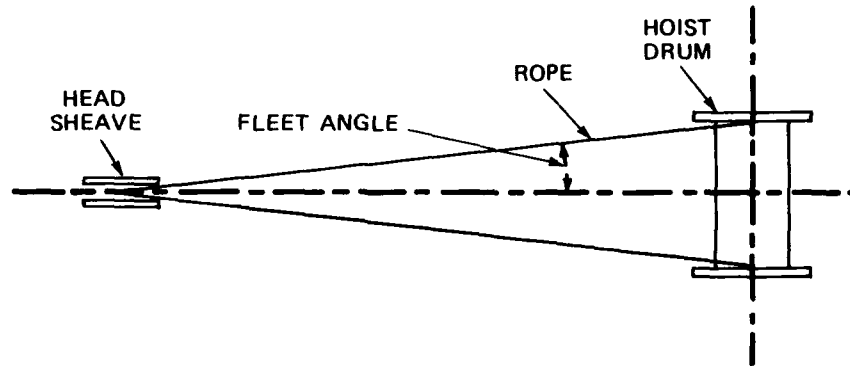
In a vertical shaft it looks like this:



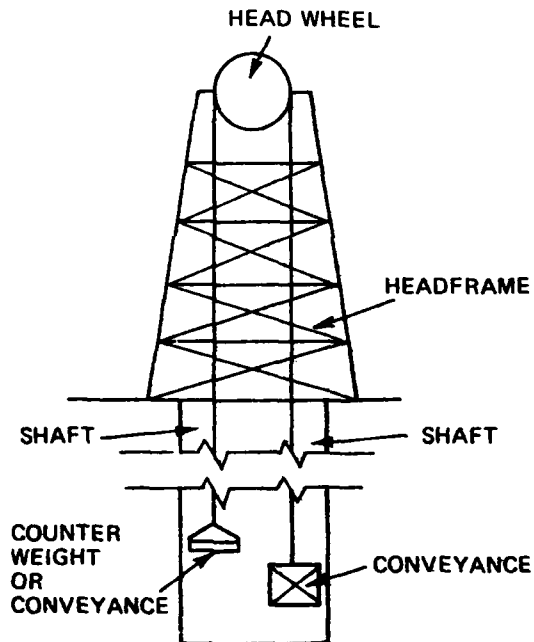
In a slope shaft an idler sheave and support replace the headsheave and headframe.



The angle between the center line of the sheave and the hoist rope is called the Fleet Angle. The fleet angle must not be more than 1 1/2 degrees for smooth drums or 2 degrees for grooved drums or excessive wear on the rope will result.



The Headframe for a Koepe or friction hoist may support the wheel and drive motor.



#### FEDERAL REGULATIONS (From Title 30 CFR)

**57.19-37 Mandatory.** Fleet angles on hoists installed after November 15, 1979 shall not be greater than one and one-half degrees for smooth drums or two degrees for grooved drums.

## PRACTICE QUESTIONS FOR HEADFRAME

Complete these sentences with the correct answers:

1. The headframe supports the \_\_\_\_\_ or \_\_\_\_\_ over a shaft.
2. The fleet angle is the angle between the hoist rope and the \_\_\_\_\_  
\_\_\_\_\_.
3. Too great a fleet angle will result in excessive wear on the \_\_\_\_\_.
4. Federal regulations state that fleet angles on hoists installed after November 15, 1979 shall not be greater than \_\_\_\_\_ degrees for smooth drums, or \_\_\_\_\_ degrees for grooved drums.

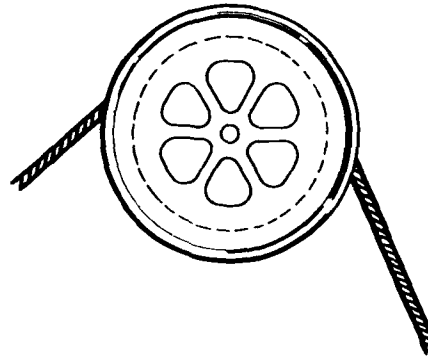
### ANSWERS TO PRACTICE QUESTIONS FOR HEADFRAME

1. head sheave; head (Koepe) wheel
2. center line of the sheave
3. rope
4.  $1\frac{1}{2}$ ; 2

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 6**

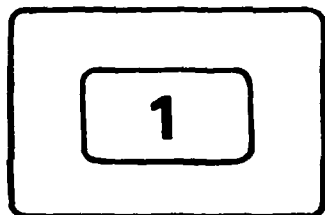
# **SHEAVES**



## **OBJECTIVE**

The trainee will know the major components  
and federal regulations for the sheaves.

## **TIME**



## **INSTRUCTIONAL OBJECTIVES FOR SHEAVES**

The trainee will be able to answer in writing fill-in-the-blank questions concerning the function (use) of sheaves.

The trainee will be able to answer in writing multiple-choice questions about the function of the head, idler, and knuckle or curve sheaves.

The trainee will be able to identify in writing the parts of the sheave.

1. Given an illustration of a sheave where each of the parts is labeled with a letter, the trainee will be able to write the name of each labeled part.
2. The trainee will be able to answer multiple-choice questions about the functions of the sheave parts.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations.

## SHEAVES

A sheave is a grooved wheel which supports the hoist rope. There are three kinds of sheaves:

- An idler sheave which supports a long length of the rope. (See Figure 1)
- A knuckle or curve sheave which supports the rope where it changes direction. (See Figure 2)
- A head sheave which supports the rope and the conveyance at the head of the shaft. (See Figure 3)

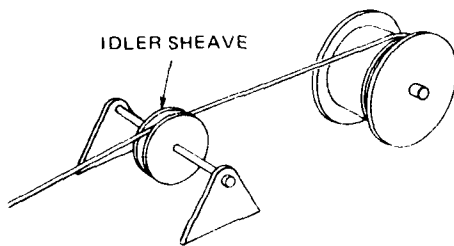


Figure 1

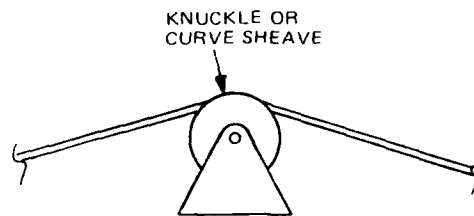


Figure 2

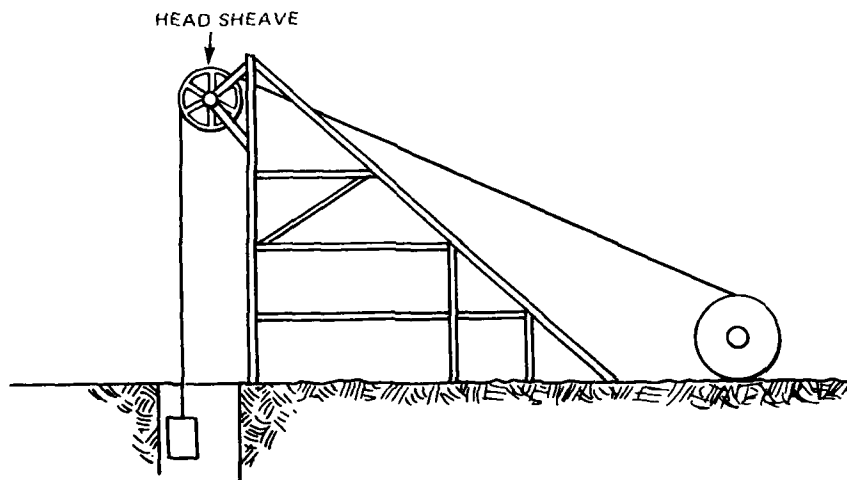


Figure 3

The critical features of a sheave are: (See Figure 4)

- groove
- diameter

The groove is the part of the sheave that the hoist rope rests on. The size of the groove must be fitted to the size of the rope. (See Figure 5)

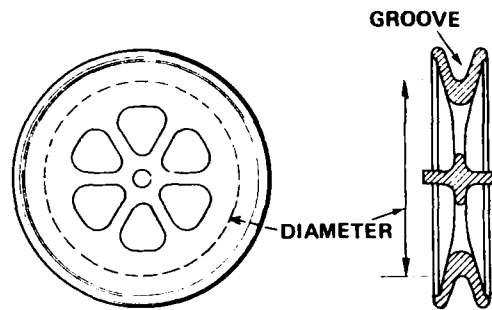


Figure 4

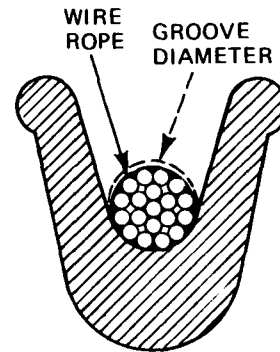


Figure 5

Too large a groove will tend to flatten the rope and cause the rope to weaken. (See Figure 6)

Too small a groove will squeeze, distort and damage the rope as well as damage the groove. (See Figure 7)

In order to save the high replacement cost of a worn sheave, liners of wear-resistant metal are used. (See Figure 8)

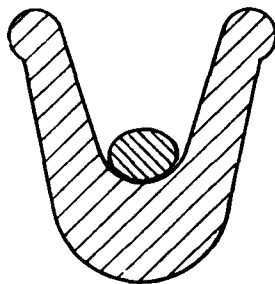


Figure 6

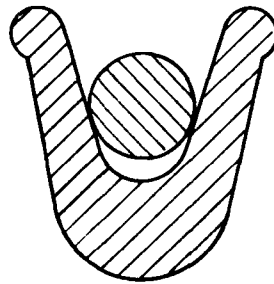


Figure 7

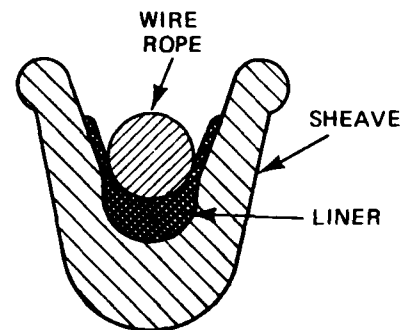


Figure 8



The size of a sheave is described by its diameter. (See Figure 4)

The diameter of the sheave must be suited to the diameter of the rope. Too small a sheave diameter will cause too sharp a bend in the rope and will damage the rope. (See Figure 9)

For the average mine hoist rope, the manufacturers recommend that the sheave diameter be 45 or more times the rope diameter. Little or no wear occurs if the sheave diameter is 90 times the rope diameter. (See Figure 10)

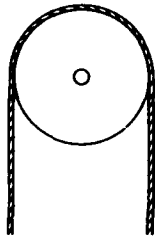


Figure 9

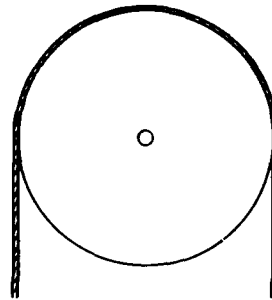


Figure 10

#### **FEDERAL REGULATIONS (From Title 30 CFR)**

##### **Metal and Nonmetallic Mines**

57.19-40 *Mandatory*. Head, idler, knuckle, and curve sheaves shall have grooves of proper contour for the specific rope diameter used.

57.19-134 *Mandatory*. Sheaves in operating shafts shall be inspected weekly and kept properly lubricated.

##### **Coal Mines**

#### **75.1400-3 DAILY EXAMINATION OF HOISTING EQUIPMENT**

The daily examination of hoisting equipment shall include:

- e) an examination of the head sheaves to check for broken flanges, defective bearings, rope alignment, and proper lubrication.

## PRACTICE QUESTIONS FOR SHEAVES

Complete the sentences below with the correct answer:

1. A sheave is a grooved wheel which \_\_\_\_\_ .
2. An idler sheave supports \_\_\_\_\_ .
3. A knuckle or curve sheave supports the rope as it \_\_\_\_\_ .
4. A head sheave supports the rope and the conveyance at the \_\_\_\_\_ .
5. The hoist rope rests on the \_\_\_\_\_ of the sheave.
6. The size of the groove must be fitted to the \_\_\_\_\_ .
7. Too large a groove will \_\_\_\_\_ and cause the rope to weaken.
8. Too small a groove will squeeze, distort and damage the rope as well as \_\_\_\_\_ .
9. To save the high replacement cost of a worn sheave, \_\_\_\_\_ can be used.
10. A larger sheave diameter prevents the rope from \_\_\_\_\_ which can cause broken wires.

## FEDERAL REGULATIONS

### Metal and Nonmetallic Mines

11. Head, idler, knuckle, and curve sheaves shall have grooves of proper contour for the specific \_\_\_\_\_ .
12. Sheaves in operating shafts shall be inspected \_\_\_\_\_ and kept properly \_\_\_\_\_ .

### Coal Mine

13. Head sheaves shall be examined \_\_\_\_\_ for \_\_\_\_\_ .

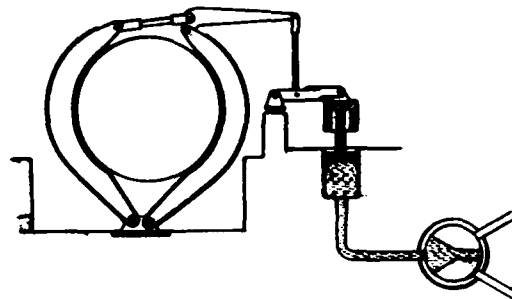
## ANSWERS TO PRACTICE QUESTIONS FOR SHEAVES

1. supports the hoist rope.
2. a long length of rope.
3. changes direction.
4. head of the shaft.
5. groove
6. size of the rope.
7. flatten the rope
8. damage the groove.
9. liners
10. making a sharp bend.
11. rope diameter.
12. weekly; lubricated.
13. daily; broken flanges, defective bearings, rope alignment, and proper lubrication.

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 7**

### **BRAKE SYSTEM**



### **OBJECTIVE**

**The trainee will know the operating principles,  
major components and federal regulations  
for the brakes**

### **TIME**

**1**

## **INSTRUCTIONAL OBJECTIVES FOR BRAKE SYSTEM**

The trainee will be able to answer in writing "fill-in-the-blank" questions concerning the function (use) of the brake system.

The trainee will be able to identify in writing each type of brake.

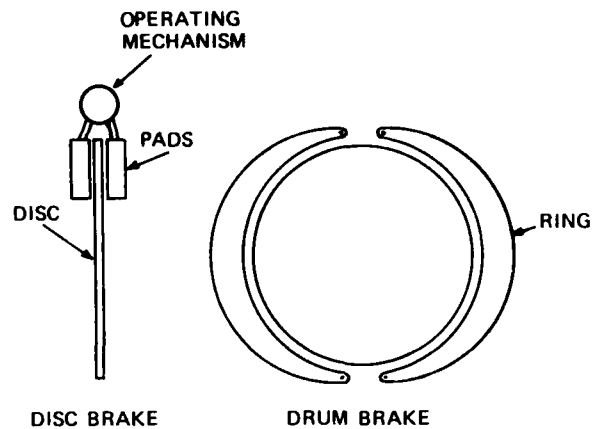
Given illustrations of disc, jaw or parallel motion brakes, the trainee will be able to label each.

The trainee will be able to describe the operating principles of the hoist brake.

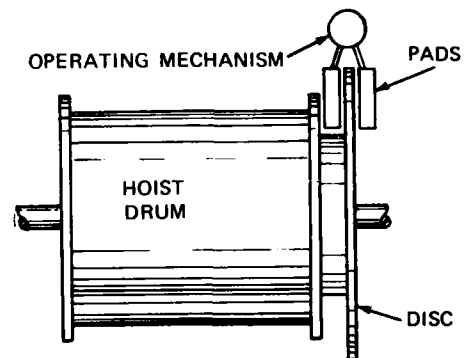
The trainee will be able to answer in writing multiple-choice questions about the brake operating principles.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for the hoist brake.

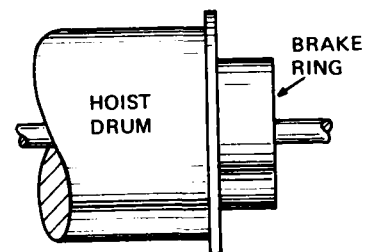
Brakes stop the hoist drum and hold it in one position. There are two types of brakes: disc, and ring or drum brakes.



The Disc Brake is connected to the hoist drum like this:

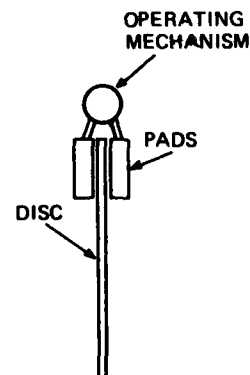


The Ring Brake is connected to the hoist drum like this:



The main parts of a Disc Brake are:

- disc
- pads
- operating mechanism

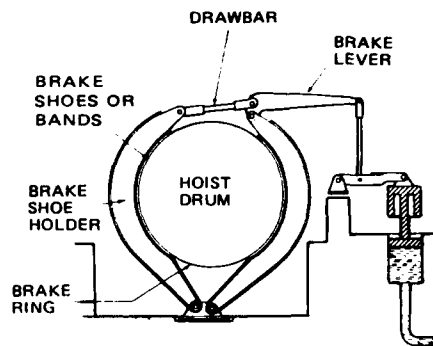


When the brake is applied the pads come together to press against the disc. This pressure prevents the disc from moving.

There are two types of Ring Brakes: jaw and parallel motion.

The main parts of a Jaw Brake are:

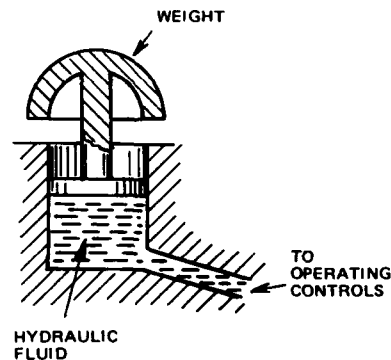
- ring
- shoes or bands
- draw bar
- operating mechanism



JAW BRAKE

The brakes are operated by a combination of hydraulic and/or pneumatic pressure and gravity or by hand through a system of levers. To apply the brakes, the hydraulic pressure on the cylinder is released. The weight can then pull down on the brake lever which by pulling on the draw bar brings the brake shoe holders together. This action causes the brake shoes to press against the ring.

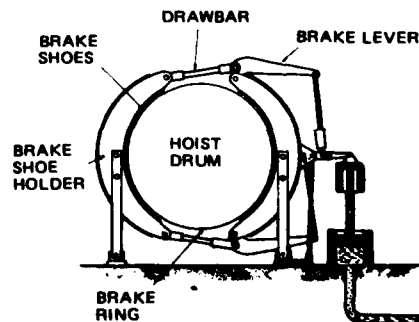
To release the brake, hydraulic pressure is restored to the cylinder. The weight is lifted, and moves the brake lever upward. This action allows the brake shoe holders to separate and lift the brake shoes from the brake ring.



A Parallel Motion Brake is similar to a jaw brake.

The main parts of a parallel motion brake are:

- ring
- shoes
- draw bars (2)
- operating mechanism



These brakes are also operated by gravity. The weight pulls on both brake levers, and through the draw bars and the brake shoe holders, presses the shoes against the ring.

#### **FEDERAL REGULATIONS (From Title 30 CFR)**

##### **Metal and Nonmetallic Mines**

57.19-4 *Mandatory.* Any hoist used to hoist men shall be equipped with a brake or brakes which shall be capable of holding its fully loaded cage, skip, or bucket at any point in the shaft.

57.19-5 *Mandatory.* The operating mechanism of the clutch of every man-hoist drum shall be provided with a locking mechanism, or interlocked electrically or mechanically with the brake to prevent accidental withdrawal of the clutch.

57.19-6 *Mandatory.* Automatic hoists shall be provided with devices that automatically apply the brakes in the event of power failure.

##### **Coal Mines**

##### **75.1400-1 HOISTS; BRAKES, CAPABILITY.**

Brakes on hoists used to transport persons shall be capable of stopping and holding the fully loaded platform, cage, or other device at any point in the shaft, slope, or incline.



## PRACTICE QUESTIONS FOR BRAKE SYSTEM

Complete this sentence with the correct answers:

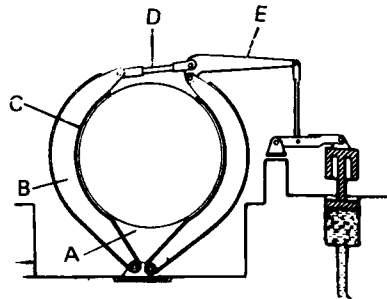
- The brakes of a mine hoist \_\_\_\_\_ and \_\_\_\_\_.
- Below is a disc brake. Label the parts and fill in the blanks to explain how this brake works.



- A. \_\_\_\_\_  
 B. \_\_\_\_\_  
 C. \_\_\_\_\_

The \_\_\_\_\_ forces the pads together to press against the disc. This pressure prevents \_\_\_\_\_ of the disc.

- The two types of ring brakes are \_\_\_\_\_ and \_\_\_\_\_.
- Below is a jaw brake. Label the parts (A-E) and fill in the blanks to explain how this brake works.



- A. \_\_\_\_\_  
 B. \_\_\_\_\_  
 C. \_\_\_\_\_  
 D. \_\_\_\_\_  
 E. \_\_\_\_\_

When the \_\_\_\_\_ is released, the weight pulls down on the \_\_\_\_\_ which pulls on the draw bar. The bands or brake shoe holders are brought together and the \_\_\_\_\_ press against the ring.

Complete these sentences with the correct answers:

- A parallel motion brake is similar to a \_\_\_\_\_ brake. Instead of one draw bar and one brake lever, the parallel motion brake has \_\_\_\_\_ and \_\_\_\_\_.

### **Metal and Nonmetallic Mines**

6. Any hoist used to hoist men shall be equipped with a brake or brakes capable of holding its fully loaded \_\_\_\_\_ at any point in the shaft.
7. The operating mechanism of the clutch of every man-hoist drum shall be provided with a locking mechanism, or interlocked electrically or mechanically with the brake to prevent \_\_\_\_\_.
8. Automatic hoists shall be provided with devices that automatically \_\_\_\_\_ in the event of power failure.

### **Coal Mines**

9. Brakes on hoists used to transport persons shall be capable of stopping and holding the fully loaded \_\_\_\_\_ at any point in the shaft, slope, or incline.

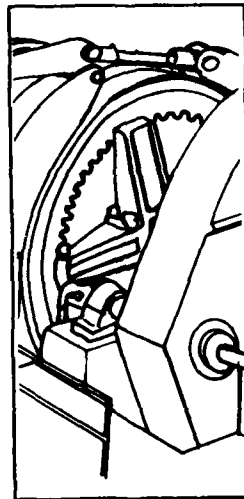
## ANSWERS TO PRACTICE QUESTIONS FOR BRAKE SYSTEM

1. stop the hoist drum or wheel; hold it in one position.
2. A. Operating Mechanism  
B. Pads  
C. Disc  
operating mechanism; movement
3. jaw; parallel motion.
4. A. Brake Ring  
B. Brake Shoe Holder  
C. Brake Shoes or Bands  
D. Drawbar  
E. Brake Lever  
hydraulic pressure; brake lever; bands or brake shoes
5. jaw; 2 drawbars; 2 brake levers
6. cage, skip or bucket
7. accidental withdrawal of the clutch.
8. apply the brakes
9. platform, cage, or other device

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 8

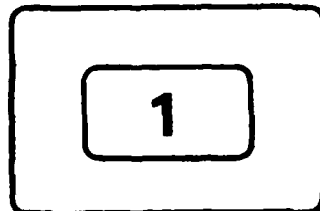
# CLUTCH



## OBJECTIVE

The trainee will know the operating principles,  
the major components and the federal regulations  
for the clutch

## TIME



## INSTRUCTIONAL OBJECTIVES FOR THE CLUTCH

The trainee will be able to answer in writing multiple-choice questions concerning the function (use) of the clutch.

The trainee will be able to identify each type of clutch.

Given illustrations of a tooth or positive engagement clutch, and a friction or band clutch, the trainee will be able to label each type in writing.

The trainee will be able to identify the parts of each type of clutch.

Given an illustration of a tooth or positive engagement clutch, and a friction or band clutch, where each part is labeled with a letter, the trainee will be able to write the name of each labeled part.

The trainee will be able to describe the operating principles for the clutch.

Given an illustration of each type of clutch, the hoist operator will be able to answer in writing multiple-choice questions about how each works.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for the hoist clutch.

## CLUTCH

The clutch is the device which engages or disengages the drum from the hoist motor. There are two basic types of clutch: the tooth or positive engagement clutch and the friction clutch.

The parts of the tooth or positive engagement clutch are: (See Figure 1)

- clutch spider
- clutch ring
- operating mechanism

The clutch spider is keyed to the hoist drum shaft.

The clutch ring is fastened to the hoist drum frame.

The arms of the spider have grooves or teeth that match those on the clutch ring.

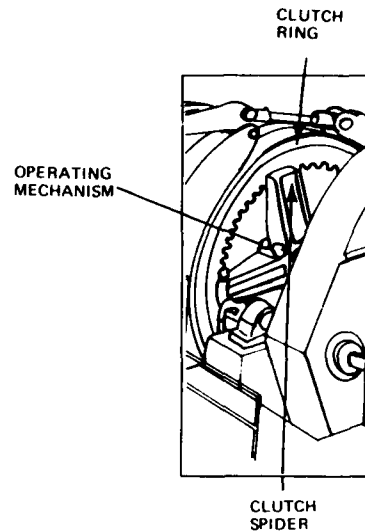


Figure 1

The operating mechanism moves the clutch spider away from or toward the clutch ring. This operating mechanism may be hydraulically or pneumatically powered.

When the clutch spider is against the clutch ring, the teeth on the spider engage with the teeth of the ring. If the drum shaft rotates, the clutch spider rotates and causes the drum to rotate.

When the clutch spider is moved away from the clutch ring, the teeth disengage and the clutch is disengaged. The shaft can then turn independently of the drum.

Some hoists have a friction or band clutch. (See Figure 2)

The parts of a friction clutch are:

- clutch ring
- clutch spider
- bands
- friction blocks
- operating mechanism

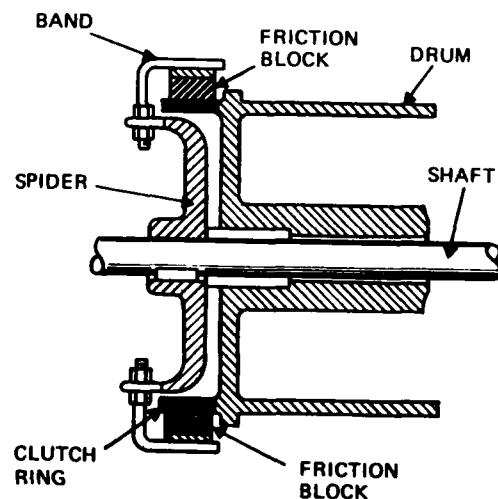


Figure 2

The clutch ring is fastened to the hoist drum frame.

The clutch spider is keyed to the hoist drum shaft.

The spider has a band on the end of each arm which supports a friction block.

- To engage the clutch, the operating mechanism causes the friction blocks to press against the clutch ring.
- Friction between the friction blocks and the ring causes the ring and the attached drum to rotate with the shaft.
- To disengage the clutch, the friction blocks are pulled away from the clutch ring

The hoist is equipped with a clutch brake interlock. This device requires that the brakes be applied to a drum before the clutch can be disengaged.

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic Mines**

57.19-5 *Mandatory.* The operating mechanism of the clutch of every man hoist drum shall be provided with a locking mechanism, or interlocked electrically or mechanically with the brake to prevent accidental withdrawal of the clutch.

### **Coal Mines**

75.1403-3 (a) The clutch of free-drums on man-hoist shall be provided with a locking mechanism or interlocked with the brake to prevent the accidental withdrawal of the clutch.

## PRACTICE QUESTIONS FOR THE CLUTCH

Complete these sentences with the correct answers:

1. The clutch is the device which \_\_\_\_\_ the drum from the hoist motor.
2. The parts of the tooth or positive engagement clutch are the \_\_\_\_\_, the \_\_\_\_\_, and the \_\_\_\_\_.
3. The \_\_\_\_\_ is keyed to the hoist drum shaft. Grooves or teeth are on the \_\_\_\_\_ of the spider. These grooves match those on the \_\_\_\_\_.
4. The \_\_\_\_\_ is fastened to the hoist drum frame.
5. The clutch spider is moved by the \_\_\_\_\_.
6. The teeth on the \_\_\_\_\_ engage with the teeth of the ring when the clutch spider is against the clutch ring. If the drum shaft rotates, the clutch spider \_\_\_\_\_ and causes the drum to \_\_\_\_\_.
7. The parts of a friction clutch are the \_\_\_\_\_, the \_\_\_\_\_, the \_\_\_\_\_, and the \_\_\_\_\_.
8. The clutch ring is fastened to the hoist \_\_\_\_\_; the clutch spider is keyed to the hoist \_\_\_\_\_; on the end of each arm the spider has a \_\_\_\_\_ which supports a friction block.
9. To engage the clutch, the \_\_\_\_\_ moves the clutch spider toward the \_\_\_\_\_. The friction blocks press against the \_\_\_\_\_; friction between the blocks and the \_\_\_\_\_ causes the ring and the attached drum to rotate with the shaft.



**FEDERAL REGULATIONS (From Title 30 CFR)**

**Metallic and Nonmetallic Mines, Coal Mines**

10. The operating mechanism of the clutch of every man hoist drum shall have a \_\_\_\_\_  
\_\_\_\_\_ or will be interlocked electrically or mechanically with the brake to  
prevent \_\_\_\_\_.

## ANSWERS TO PRACTICE QUESTONS FOR CLUTCH

1. engages or disengages
2. clutch spider; clutch ring; operating mechanism.
3. clutch spider; arms; clutch ring.
4. clutch ring
5. operating mechanism.
6. spider; rotates; rotate.
7. clutch ring; clutch spider; bands; operating mechanism.
8. drum frame; drum shaft; band
9. operating mechanism; clutch ring; clutch ring; ring
10. locking mechanism; accidental withdrawal of the clutch.

## INSTRUCTIONAL OBJECTIVES FOR HOIST DRUM OR WHEEL ASSEMBLY

The trainee will be able to write in one or two sentences the function (use) of the hoist assembly.

The trainee will be able to identify the parts of a drum and a Koepe wheel.

1. Given an illustration of a Koepe wheel or a drum hoist assembly where each part is labeled with a letter, the trainee will be able to write the name of each labeled part.
2. The trainee will be able to answer in writing multiple-choice questions about the parts.

The trainee will be able to identify the different types of hoist assemblies.

Given illustrations of a

1. single drum hoist with one or two conveyances
2. single drum hoist with a conveyance and a counterweight
3. double drum hoist
4. Koepe wheel or friction hoist

the trainee will be able to label in writing each type of illustration.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations.

## HOIST DRUM OR WHEEL ASSEMBLY

The hoist assembly lowers and raises the hoist rope into and out of the mine.

There are two basic types of mine hoist assemblies:

- The Drum hoist in which the hoist rope is wound around a cylindrical drum and stored during the hoisting cycle;
- The Friction or Koepe wheel hoist in which the rope passes over the wheel during the hoisting process. Friction between the rope and wheel moves the rope.

The drum and wheel are driven by a hoist motor through a gear train and drive shaft. Brakes are provided to slow, stop, and hold the drum or wheel in a particular position.

The parts of a drum are: (See Figure 1)

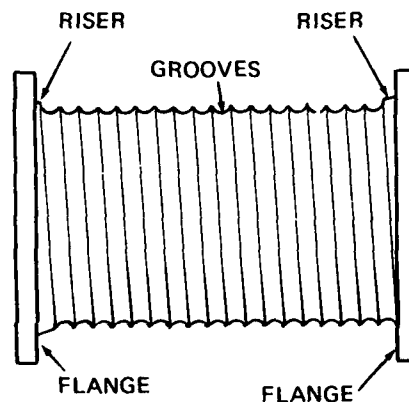


Figure 1

Flanges are the rims around the ends of the drum which prevent the rope from slipping off. Flanges must extend at least two rope diameters (minimum 4") beyond the last wrap.

Risers are metal strips that raise each successive rope layer as it winds at the ends of the drum.

A drum surface may be smooth or it may be grooved. Grooves are channels in the surface of the drum in which the rope lies. Grooves reduce wear on the hoist rope.

There are three types of grooves: (See Figure 2)

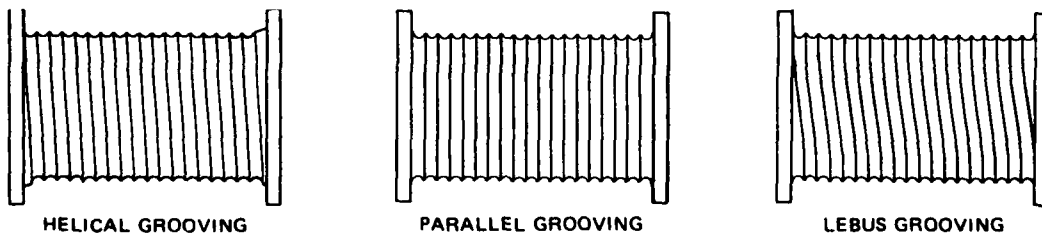


Figure 2

Helical grooving is a continuous spiral usually used for single layers of rope.

Parallel grooving is made up of evenly spaced grooves across the entire surface of the drum.

LeBus grooving is a combination of helical and parallel. One half turn is parallel and then the grooves become helical. This is used for high-speed multi-level winding.

In a Friction or Koepe wheel hoist, the drum is replaced by a wheel. The wheel may be mounted on the headframe, where the headsheave is mounted on a drum hoist. Other hoists may have the Koepe wheel located in the hoist house in place of the regular drum.

The parts of a Koepe wheel are: (See Figure 3)

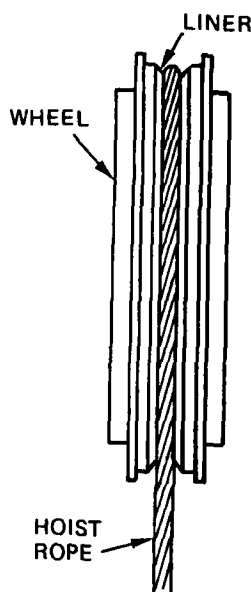


Figure 3

The liner provides a groove for the hoist rope to rest on.

The hoist assembly may take one of several forms.

Drum Hoist: Some drum hoists may have only one conveyance and no counterweight. There will be one drum and one rope. One end of the rope is attached to the conveyance, the other is attached to the drum. (See Figure 4)

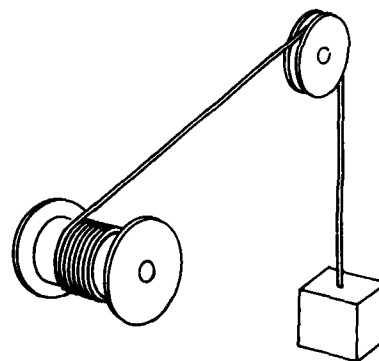


Figure 4

Other single drum hoists may have two conveyances or one conveyance and a counterweight. The ends of the rope are attached to the conveyances or to the conveyance and counterweight. The rope makes several turns around the drum. As one end of the rope is wound onto the drum, its conveyance is hoisted while the other end of the rope is unwound from the drum, and its conveyance or counterweight is lowered. (See Figure 5)

Some hoists have two drums on the same shaft; one rope is on each drum. One end of a rope is fastened to the drum and the other is fastened to the conveyance. The ropes are arranged so that when the rope on one drum is being wound, the rope on the other drum is being unwound. On most two drum hoists, a clutch is provided so that the drums can be operated separately. This clutch is particularly advantageous in a production hoist in a multi-level mine.

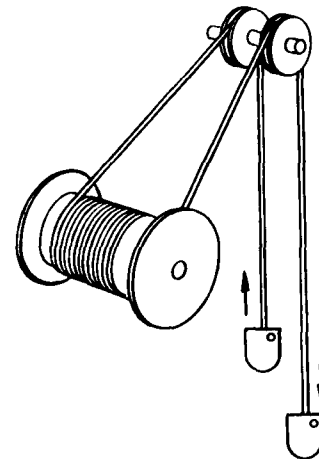


Figure 5

For example, when hauling ore from one level, one skip is at the dump unloading while the other skip is at the loading level being loaded. When the dumping and loading are completed, the loaded skip is raised to the dump while the empty skip is lowered to the loading level, and the unloading and loading operations are repeated. If the loading level is changed, one skip has to be moved in order for a skip to be at the dump while another is at the new loading level. (See Figure 6)

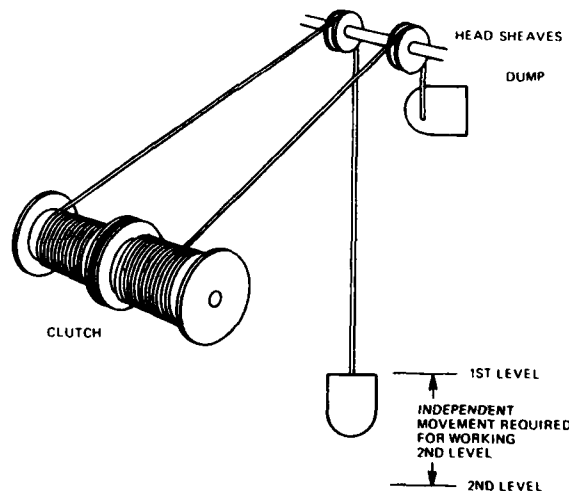


Figure 6

The Koepe Wheel or Friction hoist assembly is similar to the two conveyance one drum hoist, except that there is only one half turn of the hoist rope around the wheel. Several small ropes are normally used with the head (Koepe) wheel rather than one large rope. It is necessary that the length of each rope be equal so that the strain on each rope will be equal. (See Figure 7) Tail ropes are provided on friction hoists to compensate for the weight of the hoist ropes.

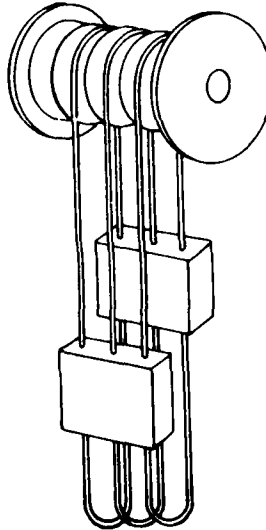


Figure 7

#### **FEDERAL REGULATIONS (From Title 30 CFR)**

##### **Metal and Nonmetallic Mines**

57.19-11 *Mandatory*. Flanges on drums shall extend radially a minimum of 4 inches or 3 rope diameters beyond the last wrap, whichever is the lesser.

57.19-12 *Mandatory*. Where grooved drums are used, the grooves shall be of suitable size and pitch for the rope used.

## PRACTICE QUESTIONS FOR HOIST DRUM OR WHEEL ASSEMBLY

Complete these sentences with the correct answers:

1. In the \_\_\_\_\_ hoist, the hoist rope is wound around a drum and stored during the hoisting cycle.
2. In the \_\_\_\_\_ hoist, the rope passes over the wheel during the hoisting cycle.
3. Metal strips that raise each successive rope layer as it winds at the ends of the drum are \_\_\_\_\_.
4. Channels in the surface of the drum in which the rope lies are \_\_\_\_\_.
5. Rims around the ends of the drum which prevent the rope from slipping off are \_\_\_\_\_.
6. Helical grooving is \_\_\_\_\_.
7. Parallel grooving is \_\_\_\_\_.
8. LeBus grooving is \_\_\_\_\_.
9. The \_\_\_\_\_ of a head (Koepe) wheel provides a groove for the hoist rope to rest on.
10. A hoist assembly may have several forms; a single drum hoist may have:
  1. \_\_\_\_\_
  2. \_\_\_\_\_
  3. \_\_\_\_\_
11. Some hoists have two drums on the same shaft. The ropes attached to each drum are arranged so that when one rope is being wound, the rope on the other drum is \_\_\_\_\_.
12. On most two drum hoists, a \_\_\_\_\_ is provided so that the drums can be operated separately.
13. Several small ropes rather than one large rope are usually used with the \_\_\_\_\_.
14. The head (Koepe) wheel may be located \_\_\_\_\_.



## FEDERAL REGULATIONS

### Metal and Nonmetallic Mines

15. Flanges on drums shall extend radially a minimum of 4 inches or 3 rope diameters beyond the last wrap, whichever is \_\_\_\_\_.
16. Where grooved drums are used, the grooves shall be of suitable \_\_\_\_\_ and \_\_\_\_\_ for the rope used.

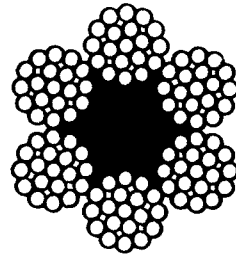
## ANSWERS TO DRUM/WHEEL PRACTICE QUESTIONS

1. drum
2. friction or head (Koepe) wheel
3. risers.
4. grooves.
5. flanges.
6. a continuous spiral usually used for single layers of rope.
7. evenly spaced grooves across the entire surface of the drum.
8. a combination of helical and parallel. One half turn is parallel and then the grooves become helical.
9. liner
10.
  1. one conveyance and no counterweight
  2. two conveyances
  3. one conveyance and one counterweight
11. being unwound.
12. clutch
13. head (Koepe) wheel.
14. in the hoist house in place of the drum; in the headframe in the head sheave position.
15. the lesser.
16. size; pitch

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 10**

# **WIRE ROPE**



## **OBJECTIVE**

The trainee will know the major components,  
usage, maintenance and inspection procedures  
and regulations for the wire rope

## **TIME**

**2 1/2**

## INSTRUCTIONAL OBJECTIVES FOR WIRE ROPE

The trainee will be able to answer in writing multiple-choice questions concerning the functions (uses) of wire rope.

The trainee will be able to describe the parts of a wire rope.

1. Given an illustration of the wire rope where each part is labeled with a letter, the trainee will be able to write the name of each labeled part.
2. The trainee will be able to answer in writing multiple-choice or matching questions about these parts.

The trainee will be able to identify different lays of rope.

Given illustrations of lays of rope, the trainee will be able to label in writing each type.

The trainee will be able to describe the procedures for making an eye.

Given illustrations of an eye being formed using U-clips, a socket, a wedge socket or an eye splice, the trainee will be able to arrange these illustrations in the order the steps are performed.

The trainee will be able to answer in writing multiple-choice questions about rope inspection and care.

The trainee will be able to calculate the rope safety factor.

Given a problem where the breaking strength and normal load are given, the trainee will be able to write the safety factor.

The trainee will be able to explain the rope designation.

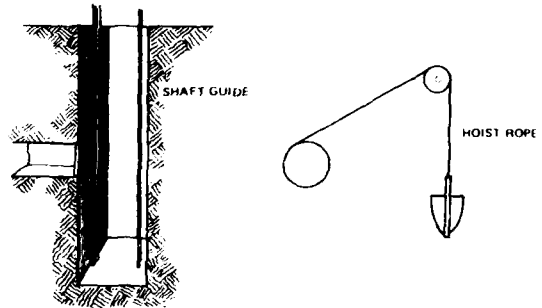
Given a rope designation, the trainee will be able to write the meaning of each number.

## WIRE ROPE

The care, installation, maintenance, and inspection of the hoist rope are engineering and/or maintenance functions. The hoist operator, however, is usually required to assist the responsible group. This unit will prepare the hoist operator to carry out his/her usual responsibilities. In mines where the hoist operator will be called upon to carry a heavier share of this load, he/she should receive further training. Many of the hoist rope manufacturers publish excellent texts which should be used for such training.

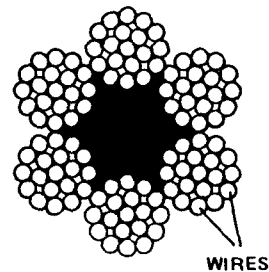
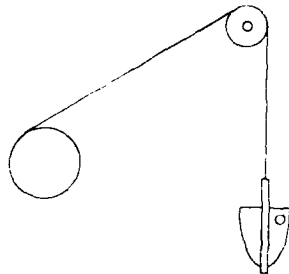
### WIRE ROPE USE

Wire rope is used for the hoist rope and, in some mines, for shaft guides. It may also be used for guy wires for structures.



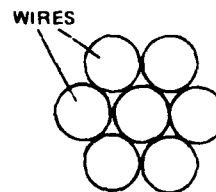
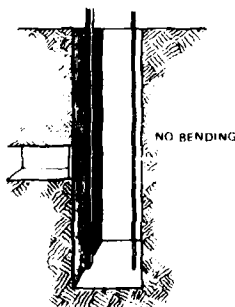
Wire rope that bends frequently while in use, the hoist rope for example, must be flexible. It is made up of many wires of small diameter.

#### BENDING AND STRAIGHTENING



Typical Crosssection

Wire rope that does not bend in use, shaft guides for example, need not be flexible. It is made up of few wires of large diameter.

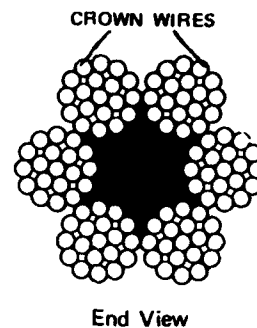


Typical Crosssection

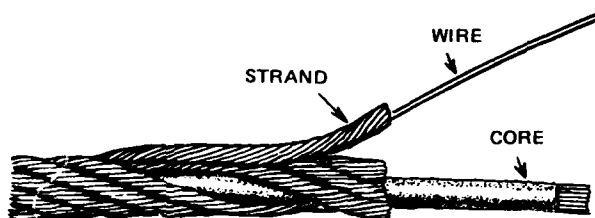
## WIRE ROPE TERMS

There are three parts to a wire rope:

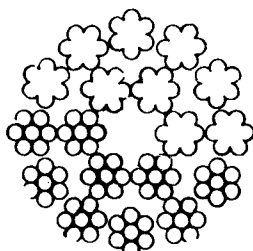
- A core which forms the center of the rope
- Wires which are twisted into strands. The wires which bear against a sheave or drum are called crown wires.
- Strands which are twisted around the core into rope.



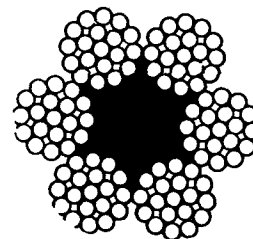
End View



Rope is designated by the NUMBER OF STRANDS X the NUMBER OF WIRES PER STRAND and ROPE DIAMETER.



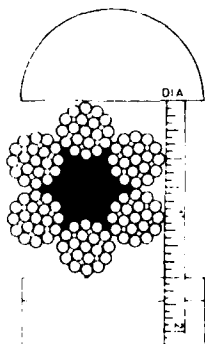
This rope has 18 strands of 7 wires each.  
It is an 18 x 7.



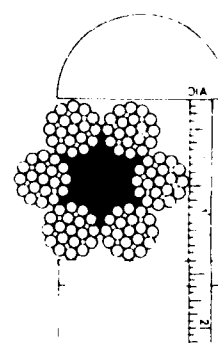
This rope has 6 strands of 19 wires each.  
It is a 6 x 19.

Rope diameter is measured like

THIS



NOT THIS



This is a 1 1/2" Rope

Lay of rope

The length of rope that it takes for one strand to make a complete turn around the core is a Lay.



Right Lay

If the strands are twisted to the right, the rope is Right Lay.



RIGHT LAY

Left Lay

If the strands are twisted to the left, the rope is Left Lay.



LEFT LAY

Regular Lay

If the strands are twisted in one direction and the wires in the other direction, the rope is Regular Lay.



REGULAR LAY

Lang Lay

If the strands and wires are twisted in the same direction, the rope is Lang Lay.



LANG LAY

### Safety Factor

The breaking strength of the rope divided by the load on the rope is the Safety Factor

$$\text{Safety Factor} = \frac{\text{Breaking Strength}}{\text{Load}}$$

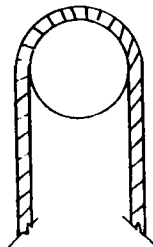
A rope with a 100,000 pound breaking strength carrying a normal load of 10,000 pounds has a Safety Factor of  $\frac{100,000}{10,000}$  or 10.

### WIRE ROPE CARE

Wire rope is expensive. Handle it carefully to prolong its life.

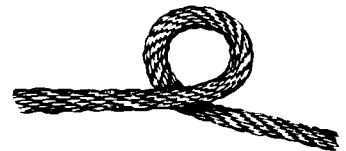
#### Avoid Sharp Bends

The use of too small a sheave or drum, or kinking will cause the wire rope to be weakened.



Too Small  
Sheave

Loop



Loop  
tightens



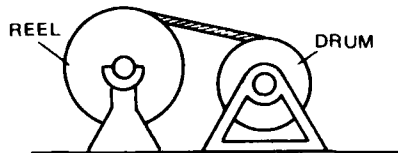
Kink



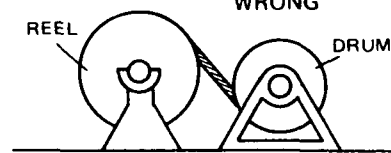
#### Avoid Reverse Bending

When transferring rope from Reel to Drum,

RIGHT



WRONG



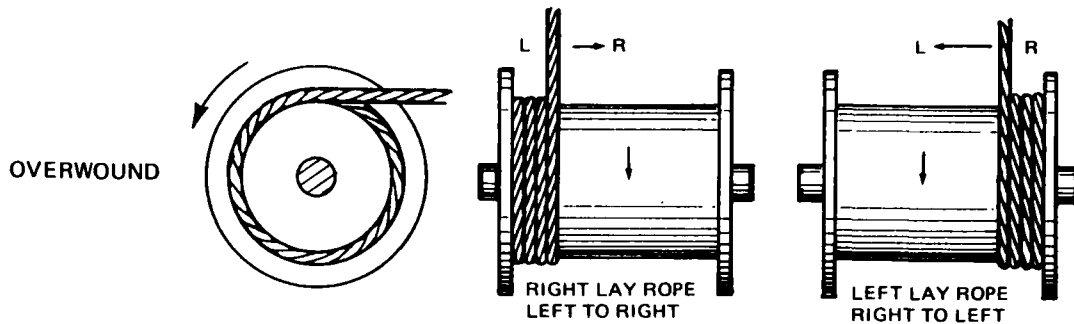
or in the rope run, reverse bending should be avoided.



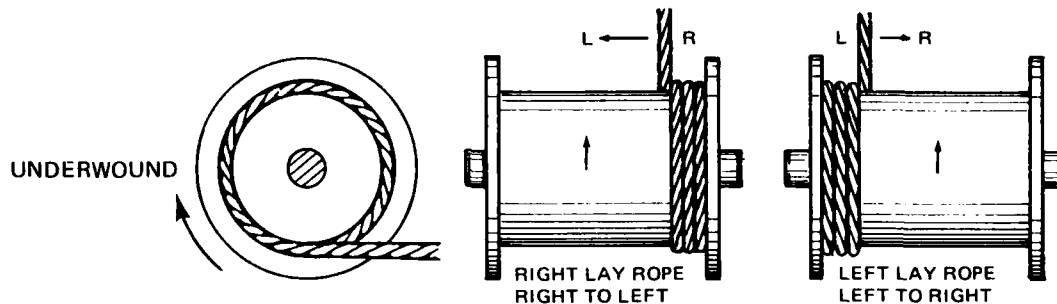


### Use Proper Rope Lay

On Overwound drums start Right Lay from Left — Left Lay from Right.



On Underwound drums start Right Lay from Right — Left Lay from Left.



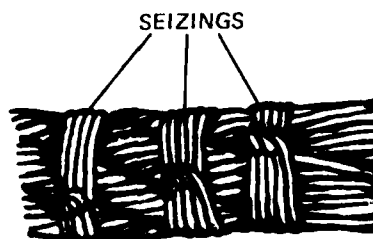
In all cases Use the Right Rope for the Job.

### **Cutting and Attaching Wire Rope**

Wire rope is weakened if its shape or structure is changed. In cutting and attaching wire rope, the shape and structure is usually preserved by "seizing," that is, wrapping the rope with small wire.

#### Cutting

At least three seizings are made on each side of the planned cut.

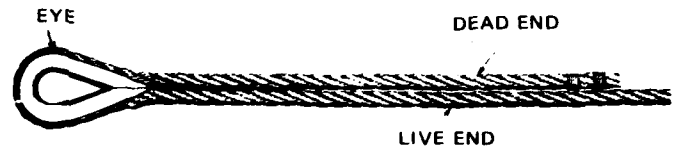


### Attaching the Wire Rope

Normally an eye is put into the end of a wire rope to attach it to a drum, conveyance, counterweight, or other object. A thimble is usually placed in the eye for support.

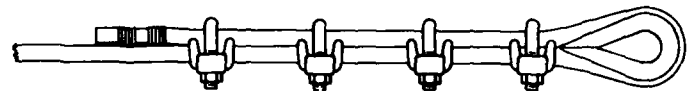
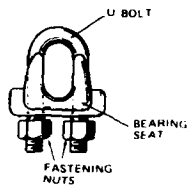
The long end of the rope is the live or working end.

The short end is the dead or bitter end.



The eye can be put into the end of the rope with:

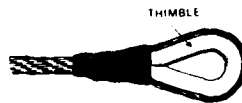
- U-Clips



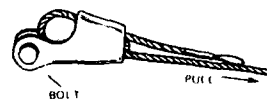
- A Socket



- An Eye Splice



- A Wedge Socket



U-Clips are often used because the process is simple and readily done by the average mechanic.

## U-Clips

With U-CLIPS the Eye is formed in 5 steps:

STEP 1 — Calculate the number of clips and the clip spacing:

The Number of Clips (N) = 3 x Rope Diameter + 1

For a 1" Rope:  $N = 3 \times 1 + 1 = 4$  clips required

Clip spacing = 6 x Rope Diameter

=  $6 \times 1 = 6$  inches.

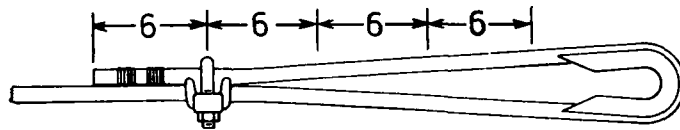
STEP 2 — Form the Eye around the Thimble.

The length of the dead end is equal to

Number of Clips x Clip Spacing =  $4 \times 6 = 24''$



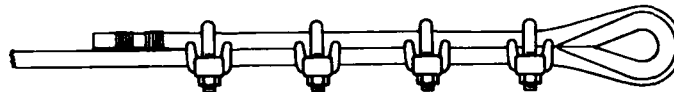
STEP 3 — Attach the U-Clip farthest from the Eye. Note that the U-Bolt touches the bitter end, NOT the working end.



STEP 4 — Attach the U-Clip nearest the Eye.



STEP 5 — Attach and tighten the remaining clips.



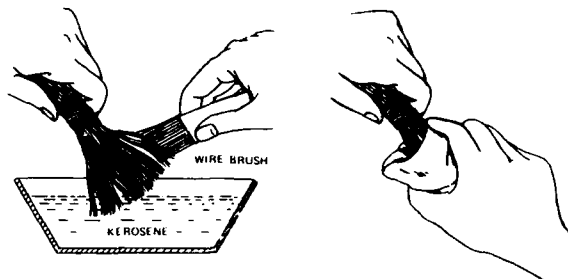
## Socket

The Eye is formed with a Socket in 5 steps:

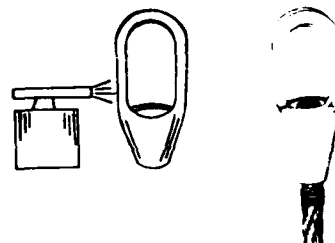
STEP 1 — Arrange the wires in the form of a brush down to the first seizing. If the rope has a non-metal core, remove the core down to the first seizing.



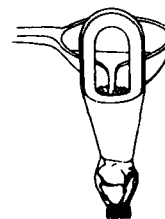
STEP 2 — Clean the "brush" with solvent (kerosene or similar); dry off solvent; dip 3/4 of brush in muriatic acid, then clean brush with a soda mixture.



STEP 3 — Heat socket to 200° F, insert brush in socket; keep brush centered and perpendicular in the socket.

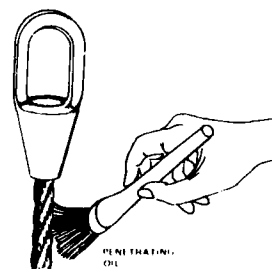


STEP 4 — Put fire clay or putty around the base of the socket and pour high grade Zinc (ASTM-SPEC. 8-6-58) heated from 850° to 1000° F into the socket.



Having the Zinc at the RIGHT TEMPERATURE is very important.

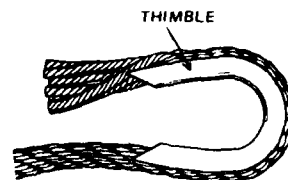
STEP 5 — Remove the fire clay and lubricate the rope up to the socket.



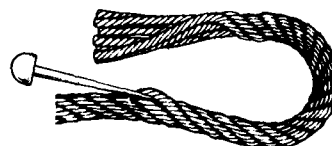
## Eye splice

The EYE is formed with a Splice in 4 steps:

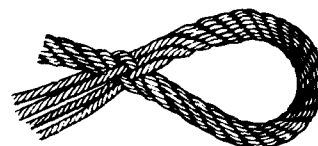
STEP 1 — Form the eye around the thimble about 1 lay from the dead end and separate the strands that extend beyond the thimble on the dead end.



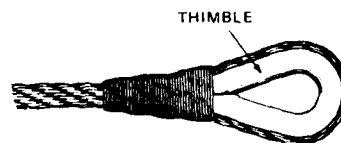
STEP 2 — Use a steel spike (MARLINSPIKE) to separate the strands on the working end.



STEP 3 — Interlace the strands from the dead end into the separations in the working end until each strand from the dead end has been laced over and under at least 3 times.



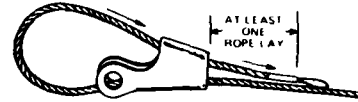
STEP 4 — Cover the spliced area with seizing wire.



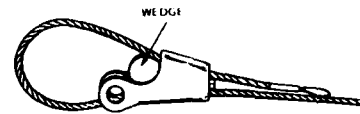
### Wedge Socket

The Eye is formed with a Wedge Socket in 4 steps:

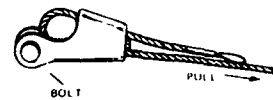
STEP 1 — Form a loop through the socket.



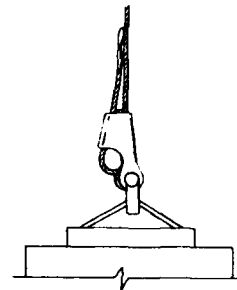
STEP 2 — Insert the wedge.



Step 3 — Pull wedge and rope into position.



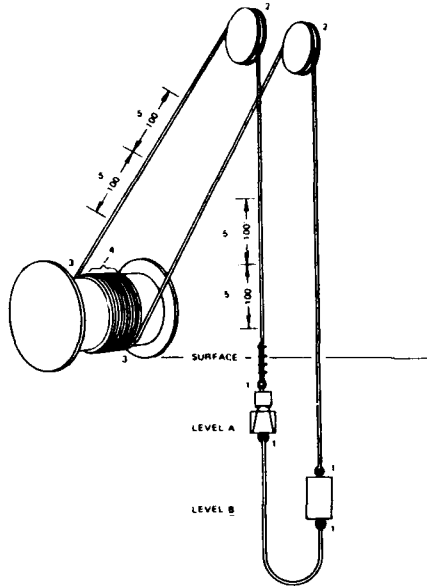
STEP 4 — Final tightening occurs under full load.



## WIRE ROPE INSPECTION

Federal Regulations require that wire ropes used for hoisting shall be inspected regularly.

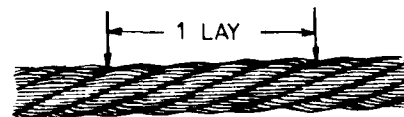
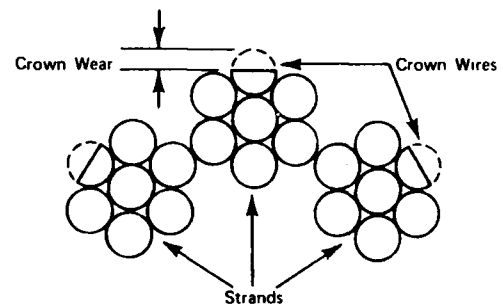
Parts of the wire rope that require close inspection are:



1. Points where the rope is connected to the conveyance and drum;
- 2., 3. & 4. Points where the rope leaves the sheaves or drums when the conveyance is at the loading levels or dump level;
5. Every 100 feet.

Defects that will require ropes to be removed from the hoist:

- Corrosion or distortion, as from a kink;
- Reduced wire rope diameter;
- 65% crown wear;
- More than 6 broken wires in one lay of rope;
- 30% crown wear and 3 broken wires in one lay;
- Dead rope; rope will not stretch under load.



Manufacturer's texts provide charts from which the ropes strength can be readily calculated if the number of broken wires in one LAY and "L", the length of wear on the crown wires, are known.

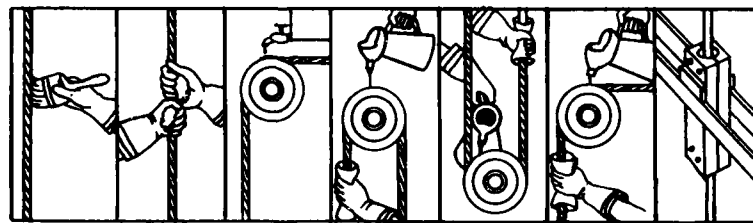
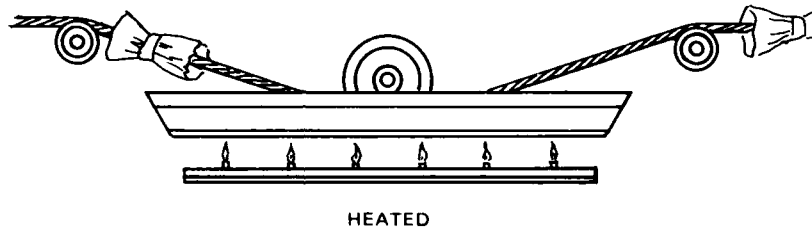
### Inspection Process

The inspector will

- Clean off a full lay of the rope surface with solvent
- Measure and record the rope diameter
- Measure and record the length of crown wear
- Note and record the number of broken wires in that lay
- Move the conveyance until the next inspection point on the rope is at the inspection station.

### LUBRICATION

Several methods of lubricating the wire rope are:



Paint it   Swab it   Drip it   Pour it   Bathe it

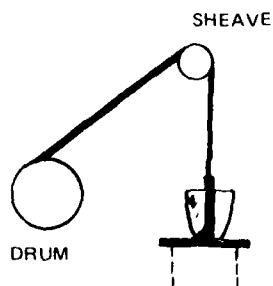
UNHEATED



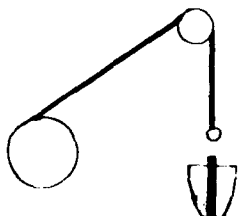
## CHANGE THE HOIST ROPE

Specific procedures for changing the hoist rope vary depending upon the type of hoist, the space available in the immediate vicinity of the hoist and the collar, and the rewinding equipment available.

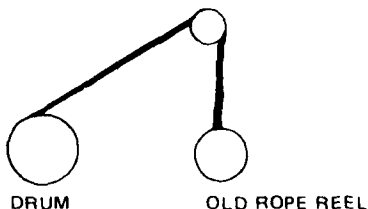
The basic procedure on a two-conveyance double-drum with no clutch hoist is as follows:



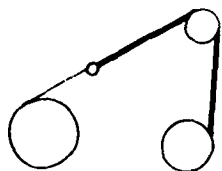
- Raise one conveyance to the highest level and block it.



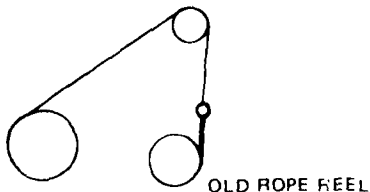
- Remove the old rope from the conveyance.



- Attach the old rope to an empty reel and transfer the old rope from the drum to the empty reel.



- When the old rope is unwound from the first drum, detach it from the drum and attach a small rope to the old rope.



- Continue winding until all of the old rope is on the reel. The small rope will extend from the drum, through the head sheave to the reel.

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MINE HOIST OPERATOR TRAINING PROGRAM. INSTRUCTION MANUAL.(U)  
DEC 79

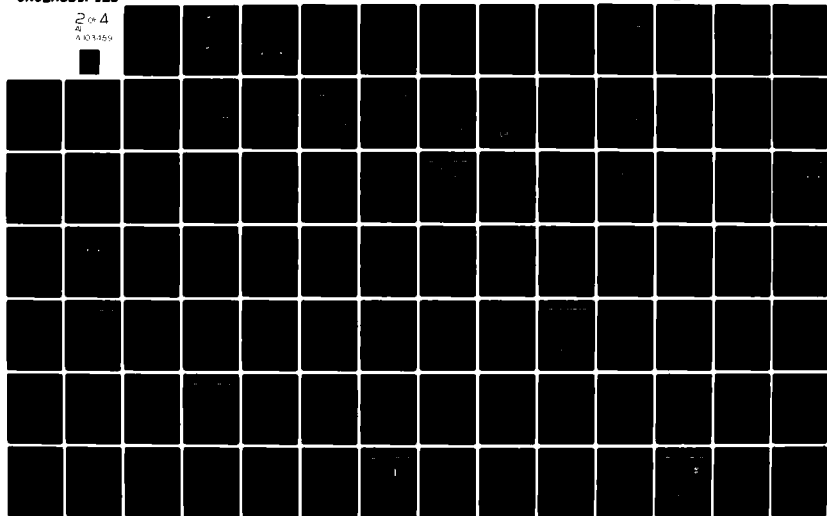
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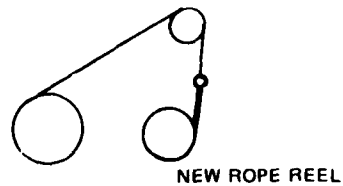
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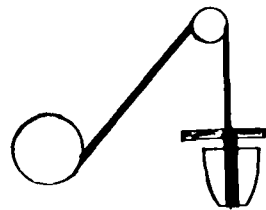
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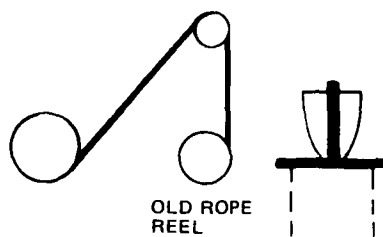




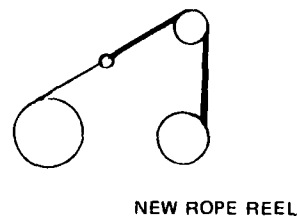
- Remove the old rope reel and attach the small rope to the new rope.



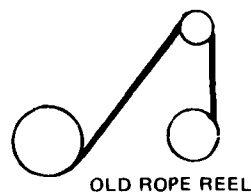
- While the first drum was unwinding, the other drum raised its conveyance to the collar.



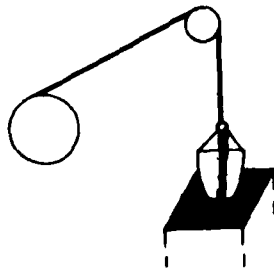
- Block the second conveyance at the proper level, remove its rope and attach the rope to a second empty reel.



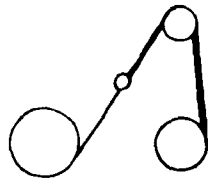
- Using the small rope, hoist the new rope for the first drum through the head sheave, attach it to the drum, and wind the new rope on the empty drum.



- As you do this, the old rope on the other drum will be transferred to the empty reel.

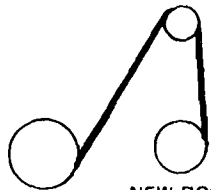


- When the new rope is wound on its drum remove it from the reel, attach it to the conveyance and unblock the conveyance.



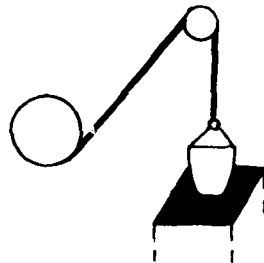
NEW ROPE REEL

- When the old rope from the second drum is unwound, detach it and use a small rope to bring the new rope to the drum as you did before.



NEW ROPE REEL

- Wind the new rope onto the empty drum. The first conveyance will be lowered as this is done.



- Attach the rope to the second conveyance and unblock that conveyance.

If the hoist has a clutch, the clutch may be disengaged and the positions of the conveyance adjusted so that one is at the loading level when the other is at the dump after the job is done.

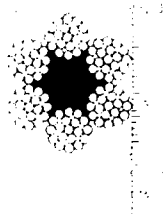
If there is no clutch the adjustments must be made while attaching the ropes to the drums. These are critical adjustments and will probably be made or supervised by the Mine Engineer.

## PRACTICE QUESTIONS FOR THE WIRE ROPE

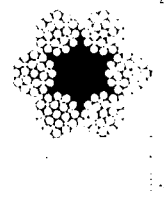
Complete these sentences with the correct answer:

1. Wire rope is used for \_\_\_\_\_, shaft \_\_\_\_\_ and \_\_\_\_\_ wires for structures.
2. If wire rope bends frequently in use, it should be \_\_\_\_\_.
3. Wire rope that is flexible is made up of many wires of \_\_\_\_\_ diameter.
4. Wire rope that doesn't bend in use is made up of few wires of \_\_\_\_\_ diameter.
5. There are three parts to wire rope; list them:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
6. A \_\_\_\_\_ forms the center of the rope; \_\_\_\_\_ are twisted into strands; \_\_\_\_\_ are twisted around the core into rope.
7. Explain what this designation for wire rope means:  
12 x 5 \_\_\_\_\_
8. Circle the correct method of measuring rope diameter:

A



B



9. A \_\_\_\_\_ is the length of rope it takes for one strand to make a complete turn around the core.

10. A right lay is twisted \_\_\_\_\_; a left lay is twisted \_\_\_\_\_.
11. A \_\_\_\_\_ of rope has the strands twisted in one direction and the wires twisted in the other direction.
12. A \_\_\_\_\_ of rope has the strands and the wires twisted in the same direction.
13. A rope with a 2,000 pound breaking strength carrying a normal load of 200 pounds has a safety factor of \_\_\_\_\_.
14. To prolong the life of the rope, avoid \_\_\_\_\_ bends and \_\_\_\_\_ bending.
15. The shape and structure of wire rope is usually preserved in cutting and attaching by \_\_\_\_\_.
16. To attach the wire rope to a drum, conveyance or other object, an \_\_\_\_\_ is put into the end and a \_\_\_\_\_ is placed in the \_\_\_\_\_ for support.
17. The eye can be attached to the rope with \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_.
18. The long end of the rope is the \_\_\_\_\_ or \_\_\_\_\_ end; the short end is the \_\_\_\_\_ or \_\_\_\_\_ end.
19. To form an eye with a socket:
- A. Arrange wires in the form of a \_\_\_\_\_ down to the first \_\_\_\_\_.  
If the rope has a nonmetal core, remove the core down to the first \_\_\_\_\_.
  - B. Clean the "brush" with \_\_\_\_\_; dry off \_\_\_\_\_.  
Dip 3/4 of brush in \_\_\_\_\_. Clean brush with \_\_\_\_\_.
  - C. Heat the \_\_\_\_\_ to 200° F; insert brush in \_\_\_\_\_.  
Keep brush \_\_\_\_\_ and perpendicular in the socket.
  - D. Put \_\_\_\_\_ or \_\_\_\_\_ around the base of the socket and pour high grade \_\_\_\_\_ heated from 850° to 1000° F, into the \_\_\_\_\_.
  - E. Remove the \_\_\_\_\_ and \_\_\_\_\_ the rope up to the socket.

20. To form an eye with a splice:

- A. Form the eye around the \_\_\_\_\_ about 1 lay from the \_\_\_\_\_ end and separate the \_\_\_\_\_ that extend beyond the \_\_\_\_\_ on the \_\_\_\_\_ end.
- B. Use a \_\_\_\_\_ to separate the strands on the \_\_\_\_\_ end.
- C. Interlace the strands from the \_\_\_\_\_ end into the \_\_\_\_\_ in the working end until each strand from the \_\_\_\_\_ end has been \_\_\_\_\_ over and under at least \_\_\_\_\_ times.
- D. Cover the spliced area with \_\_\_\_\_ wire.

21. To form an eye with a wedge socket:

- A. Form a \_\_\_\_\_ through the socket
- B. Insert the \_\_\_\_\_
- C. Pull \_\_\_\_\_ and \_\_\_\_\_ into position
- D. Final tightening occurs \_\_\_\_\_

22. Parts of the wire rope that require close inspection are:

- A. Points where the rope is \_\_\_\_\_ to the conveyance
- B. Points where the rope leaves the \_\_\_\_\_ or \_\_\_\_\_ when the conveyance is at the loading or \_\_\_\_\_ level
- C. Every \_\_\_\_\_ feet.

23. Defects that require ropes to be removed from the hoist are:

- A. More than \_\_\_\_\_ broken wires in one lay of rope
- B. Crown wear of \_\_\_\_\_ %.
- C. Corrosion or \_\_\_\_\_, as from a kink
- D. Reduced \_\_\_\_\_
- E. Rope doesn't stretch under load; \_\_\_\_\_ rope
- F. 3 broken wires in one lay and \_\_\_\_\_ % crown wear

24. To inspect the wire rope, the trainee will:

- A. Clean off a \_\_\_\_\_ lay of the rope surface with \_\_\_\_\_
- B. Measure and record the rope \_\_\_\_\_
- C. Measure and record the length of \_\_\_\_\_
- D. Note and record the number of \_\_\_\_\_ in that lay
- E. Have the conveyance moved until the next \_\_\_\_\_ point on the rope is at the \_\_\_\_\_

25. The rope may be lubricated by the heat method or may be lubricated unheated by \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, or \_\_\_\_\_.
26. The basic procedure for changing the hoist rope on a two-conveyance, double drum with no clutch hoist is:
- A. Raise one conveyance to the highest level and \_\_\_\_\_
  - B. Remove the \_\_\_\_\_ from the conveyance
  - C. Attach the old rope to an \_\_\_\_\_ and transfer the old rope from the drum to the \_\_\_\_\_
  - D. When the old rope is unwound from the first drum, detach it from the \_\_\_\_\_ and attach a \_\_\_\_\_ to the old rope
  - E. Continue winding until \_\_\_\_\_ is on the reel. The small rope will extend from the drum, through the head sheave to the \_\_\_\_\_
  - F. Remove the old rope reel and attach the small rope to the \_\_\_\_\_
  - G. While the first drum was unwinding, the other drum raised its \_\_\_\_\_ to the collar
  - H. Block the second conveyance at the proper level, remove its \_\_\_\_\_ and attach the rope to a second \_\_\_\_\_
  - I. Using the small rope, hoist the new rope for the first drum through the head sheave, attach it to the \_\_\_\_\_ and wind the new rope on the empty \_\_\_\_\_
  - J. As you do this, the old rope on the other drum will be transferred to the \_\_\_\_\_
  - K. When the new rope is wound on the first drum, detach it from the \_\_\_\_\_, attach it to the \_\_\_\_\_ and unblock the conveyance
  - L. When the old rope from the second drum is unwound, detach it and use a small rope to bring the new rope to the \_\_\_\_\_ as you did before.
  - M. Wind the new rope onto the \_\_\_\_\_
  - N. Attach the \_\_\_\_\_ to the second conveyance and unblock \_\_\_\_\_



## ANSWERS TO WIRE ROPE PRACTICE QUESTIONS

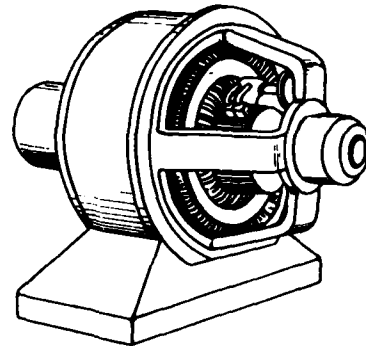
1. hoist rope; guides; guy
2. flexible.
3. small
4. large
5. A. core  
B. wire  
C. strand
6. core; wires; strands
7. This rope has 12 strands of 5 wires each
8. A
9. lay
10. to the right; to the left
11. regular lay
12. lang lay
13. 10.
14. sharp; reverse
15. seizing.
16. eye; thimble; eye
17. U-clips; socket; wedge socket; eye splice
18. live; working; dead; bitter
19. A. brush; seizing; seizing  
B. solvent; solvent; muriatic acid; soda mixture  
C. socket; socket; centered  
D. fire clay; putty; Zinc; socket  
E. fire clay; lubricate
20. A. thimble; dead; strands; thimble; dead  
B. steel spike or marlinspike; working  
C. dead; separations; dead; laced; 3  
D. seizing

21. A. loop  
B. wedge  
C. wedge; rope  
D. under full load
22. A. connected  
B. sheaves; drums; dump  
C. 100
23. A. 6  
B. 65%  
C. distortion  
D. rope diameter  
E. dead  
F. 30
24. A. full; solvent  
B. diameter  
C. crown wear  
D. broken wires  
E. inspection; inspection station
25. painting, swabbing, dripping; pouring; bathing
26. A. block it  
B. old rope  
C. empty reel; empty reel  
D. drum; small rope  
E. all of the old rope; reel  
F. new rope  
G. conveyance  
H. rope; empty reel  
I. drum; drum  
J. empty reel  
K. reel; conveyance  
L. drum  
M. empty drum  
N. rope; that conveyance

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 11**

### **ELECTRICAL SYSTEM (GENERAL)**



#### **OBJECTIVE**

The trainee will know the operating principles,  
major components and safety guidelines  
for the electrical system

#### **TIME**

**4**

## INSTRUCTIONAL OBJECTIVES FOR THE ELECTRICAL SYSTEM

The trainee will be able to write in one or two sentences the function of the electrical system.

The trainee will be able to answer in writing questions concerning the basic principles of:

1. electricity
2. magnetism
3. direct current motors
4. alternating current motors
5. direct current generators
6. alternating current generators

The trainee will be able to answer in writing questions concerning the safety precautions for electricity.

## BASIC ELECTRICAL PRINCIPLES

Electricity provides energy for operating the mine hoist and other equipment and for lighting and heating. (See Figure 1)

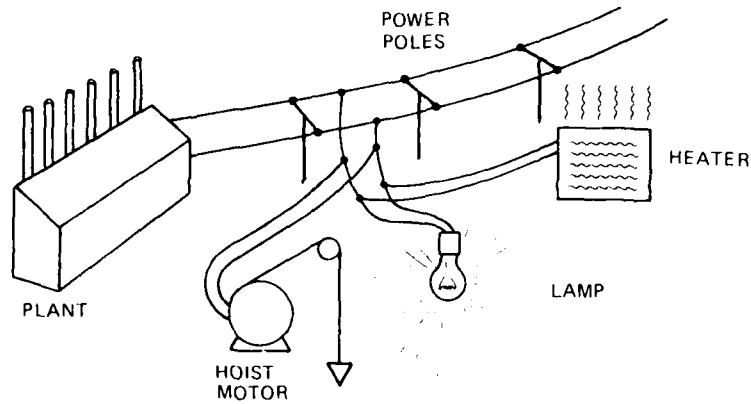


Figure 1

Like other forms of energy, electricity, if not carefully controlled, can cause injuries to people and damage to equipment.

A knowledge of the material in this unit will enable the hoist operator to operate the mine hoist and its supporting equipment with a high degree of safety from electrical hazards.

We can't actually see electricity flow through a wire and do work for us. We can, however, readily understand its basic operating principles by comparing it to a simple power system. A water power system is one that is easily understood.

An electrical power system is similar to a water power system. Figure 2 is a sketch of a water powered system. Water is stored behind the dam and creates a pressure to force water through the pipe. When the valve is opened water flows through the pipe and turns the water wheel. The greater the pressure the greater the rate of flow of water. The greater the flow of water the greater the amount of power generated by the turning wheel.

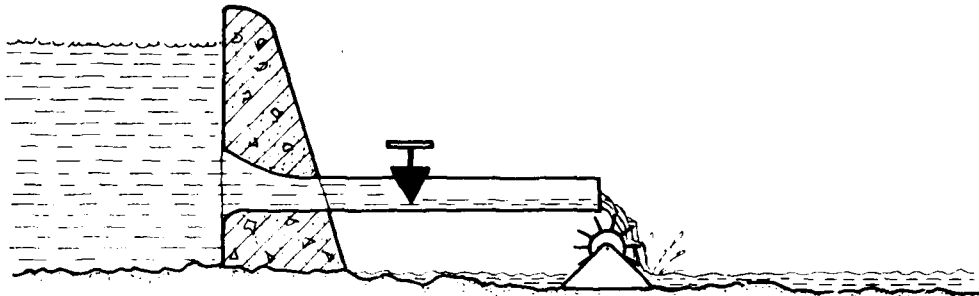


Figure 2

We can restrict the flow of water at fixed pressure by using a smaller pipe. (See Figure 3)  
We start or stop the flow of water with a valve. (See Figure 4)

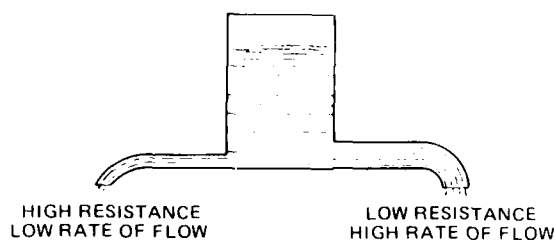


Figure 3

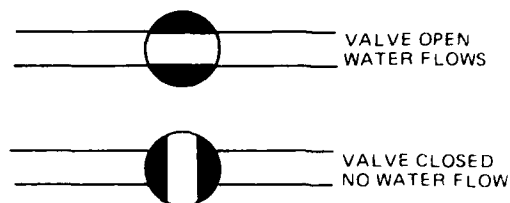


Figure 4

In an electrical system, Figure 5, we have a similar situation. Electricity is like the water. It comes from a battery or generator and flows through wires or conductors. The pressure that forces it through the conductors is the voltage. The rate of flow of electricity is the current. Voltage is measured in volts with a voltmeter; current is measured in amperes with an ammeter. (See Figure 6) The greater the number of volts, the greater the number of amperes and the greater the amount of power, light, or heat that is produced.

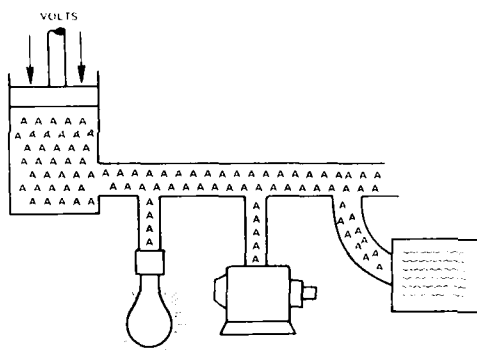


Figure 5

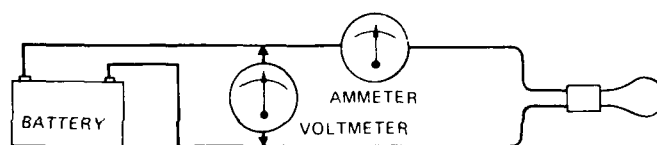


Figure 6

We can restrict the flow of current at a fixed voltage by placing resistance in the circuit. (See Figure 7) We start or stop the flow of current with a switch. (See Figure 8)

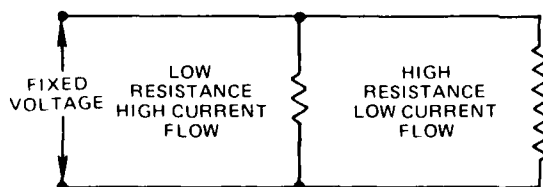


Figure 7

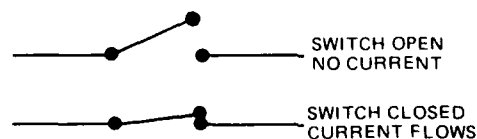


Figure 8

Too much pressure in a water system will increase the flow of water to the point that the pipes or equipment will be damaged. (See Figure 9)

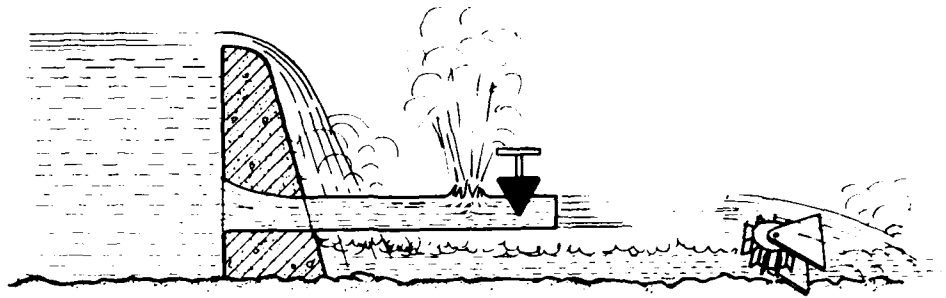


Figure 9

Too much voltage in an electrical system will increase the current to the point that the conductors or equipment will be damaged. (See Figure 10)

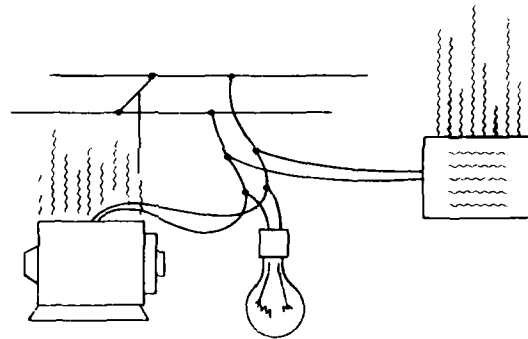


Figure 10

There are two kinds of electricity: Direct Current and Alternating Current. With direct current the voltage causes the current to flow in one direction only. The voltage may vary in the amount but not in the direction. (See Figure 11)

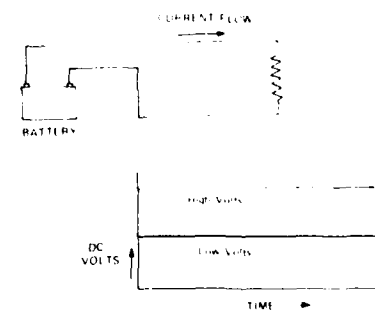


Figure 11

For alternating current the voltage causes current to flow first in one direction, then in the opposite direction. The voltage starts at zero, rises to a peak in one direction, drops to zero then to a peak in the opposite direction, then rises back to zero. (See Figure 12)

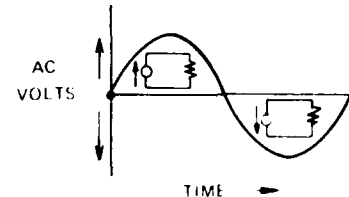


Figure 12

Most commercial electricity is generated and transmitted to the customer as alternating current. Some mine hoists and other mine equipment operate on alternating current while others operate on direct current. Where direct current is used the alternating current must be changed to direct current. A motor generator set (alternating current motor driving a direct current generator) or a rectifier is used for this purpose. (See Figure 13)

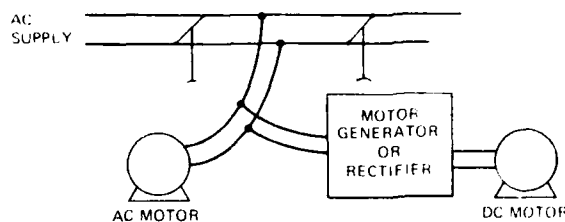


Figure 13

Now go to the Questions and answer 1 through 11

## ELECTRICITY AND MAGNETISM

The hoist motor and motor generator operate as they do because of certain relationships between electricity and magnetism. This section will explain those relationships.

If direct current electricity flows through a coil of wire that is wrapped around a piece of iron ("core") in the direction shown by the arrow →, the iron will become a magnet. The magnetic lines of force are indicated. The magnet's North and South Poles will be as indicated by S and N. (See Figure 14). This kind of magnet is called an electromagnet since it is created by electricity.

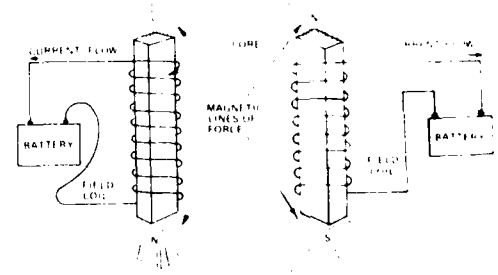


Figure 14



Opposite poles, an N and S, attract each other. (See Figure 15) Like poles, N and N or S and S repel each other. (See Figure 16)

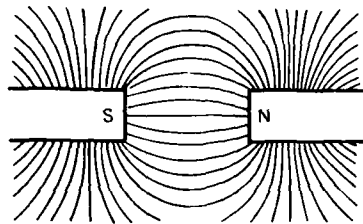


Figure 15

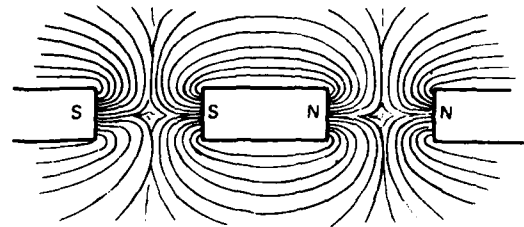


Figure 16

There are electromagnets inside the mine hoist motors. The attracting and repelling forces between the magnets cause the shaft of the hoist motor to turn.

In Figure 17A a wire is passed from left to right through the magnetic field. A voltage is generated in the wire. If the two ends of the wire are connected, current will flow.

In Figure 17B the direction of motion of the wire through the magnetic field is from right to left. The current flow is in the opposite direction from Figure 17A.

In Figure 17C the position of the poles of the magnetic field are opposite to those in Figure 17A. Changing the position of the poles changes the direction of current flow.

If the strength of the field is increased and/or the speed of the wire passing through the field is increased the voltage generated is increased.

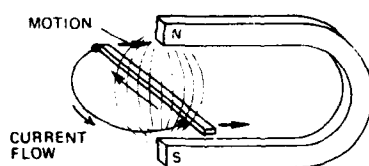


Figure 17A

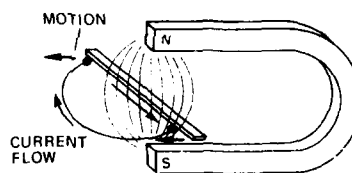


Figure 17B

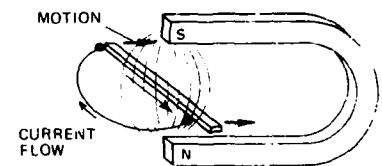


Figure 17C

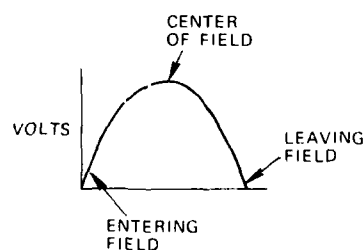


Figure 18

The voltage in the wire changes as the wire passes through a magnetic field. It is:

- Low on entering the field
  - At a peak in the center of the field
  - Low on leaving the field
- (See Figure 18)

The generator that supplies power to the hoist motor operates on these principles. Control of the hoist motor is also affected by these principles.

Now go to the Questions and answer 12 through 16

## ELECTRIC MOTORS AND GENERATORS

The hoist motor changes electrical energy into rotary motion. The generator that supplies power to the hoist changes rotary motion into electricity. Since there are differences between alternating current and direct current motors and generators we will describe them separately.

Direct Current Motor: It has four principal parts: (See Figure 19)

- The field magnets which are mounted in the motor frame. The field magnets are electromagnets (that is, cores wrapped in coils of wire.)
- The armature which is the rotating part of the motor and mounted inside the motor frame. The armature consists of several electromagnets (cores with their coils) mounted on a shaft.
- The commutator which is a series of segments of a circle arranged around and attached to the armature shaft. Each segment is connected to one of the armature's electromagnet coils.
- The brushes are attached to the motor frame and touch the commutator. They provide a path for electricity from the power supply through the commutator to the electromagnet coils in the armature. (See Figure 20)

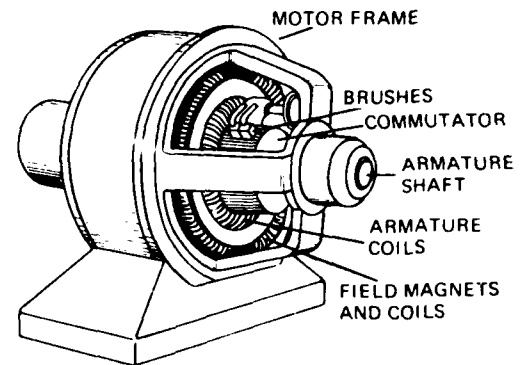


Figure 19

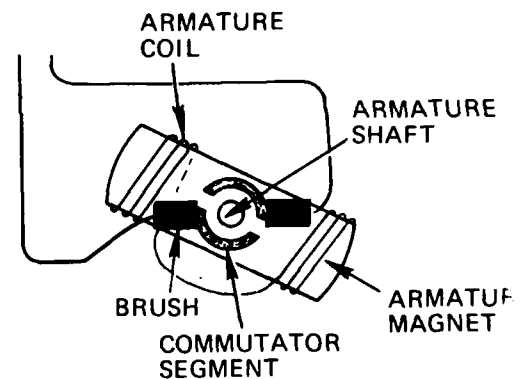


Figure 20

A Direct Current Motor operates on these principles:

- If we reverse the flow of current through the coil of an electromagnet, the poles of the magnet are reversed.
- Opposite poles attract each other.
- Like poles repel each other.

Industrial motors, like the one in Figure 19, have several armature magnets with two commutator segments for each one. They may also have more than one field magnet. In order to explain the operation of a direct current motor we will use a simple motor which has only these parts:

- One field magnet
- One armature magnet
- Two commutator segments

Note in Figures 21 through 23 that the poles of the field magnet do not change.

In Figure 21 the armature poles are the same. The nearest field poles, therefore, are being repelled, causing a clockwise rotation of the armature.

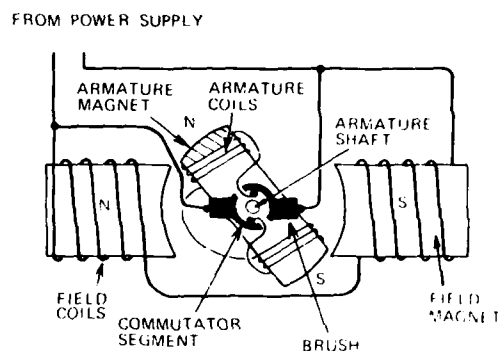


Figure 21

In Figure 22 the armature has continued its clockwise movement and the armature poles are being attracted by the opposite field poles.

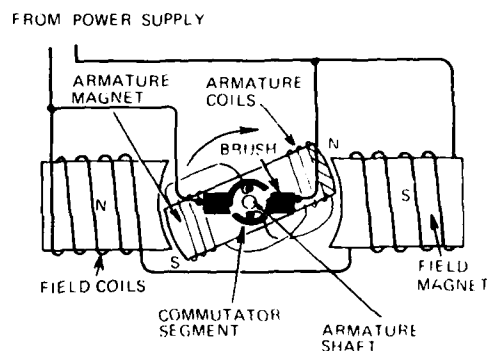


Figure 22

In Figure 23 the armature has passed through the horizontal position and the brushes have switched to opposite segments of the commutator. Current flow in the armature coils is reversed; the armature poles are reversed and are now being repelled by the field poles to continue the clockwise motion. The rotary motion of the armature can be used to turn the hoist drum, hydraulic pump and other machinery.

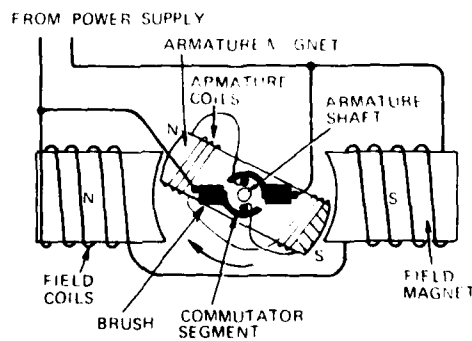


Figure 23

Increasing or decreasing the armature current will increase or decrease the magnetic forces which turn the armature and therefore, increase or decrease the power output of the motor. (See Figure 24)

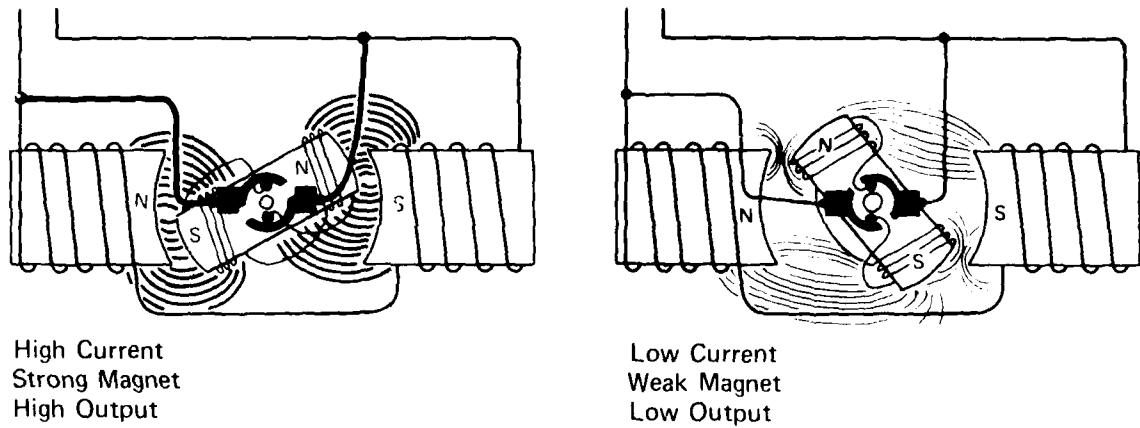


Figure 24

Now go to the Questions and answer 17 through 22

### DIRECT CURRENT GENERATOR

A direct current generator has the same parts as a direct current motor.

- Direct current from an outside source flows through the field coils.
- A power source, turbine, diesel or gasoline engine, or motor turns the armature.
- As the armature coils pass through the magnetic fields a voltage is generated in the coils. This causes current to flow in the coils.
- The current flows to the commutator and through the brush circuit to the machine, light or appliance where it will be used. (See Figure 25)

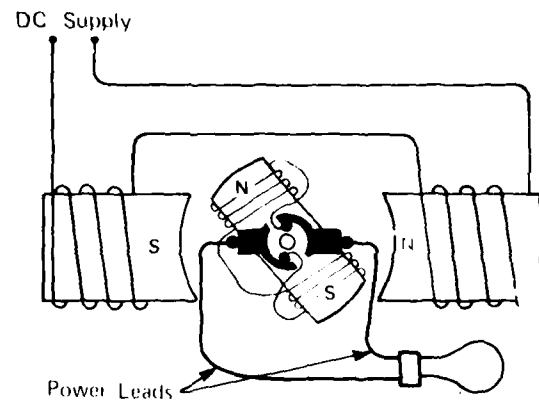


Figure 25

- Increasing the strength of the magnetic field and/or increasing the speed of the armature increases the generated voltage. (See Figure 26)

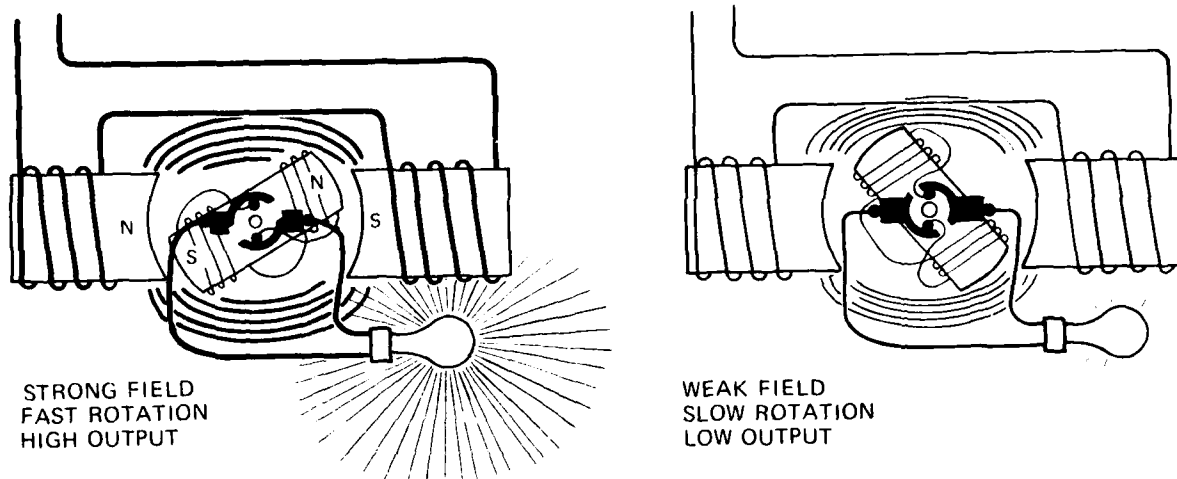


Figure 26

- The voltage generated in the coils reverses itself each time that it passes a different pole. This would cause alternating current to flow. (See Figure 27)

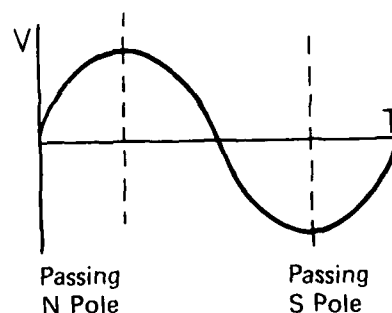


Figure 27

However, the commutator switches the end of the coils from one power lead to another as the voltage reverses itself. The switching keeps the voltage in the power leads going in the same direction. (See Figure 28)

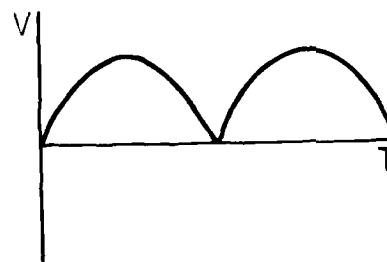


Figure 28

Industrial generators have many armature coils and the current flows into the power leads at peak voltage. The output has little more than a slight ripple. (See Figure 29)

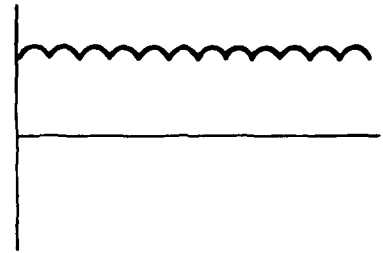


Figure 29

### ALTERNATING CURRENT GENERATOR

In a direct current generator a magnetic field was created in the field coils and voltage was generated in the armature coils. (See Figure 30)

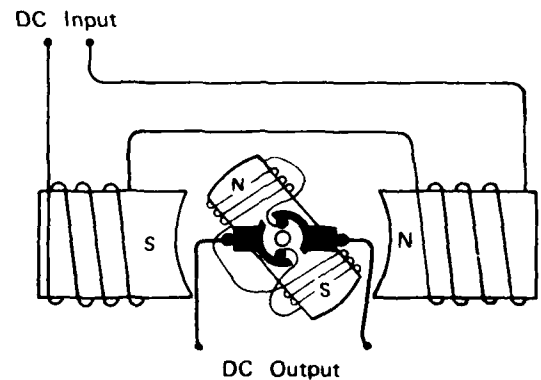


Figure 30

In an alternating current generator the magnetic field is created in the armature. DC current flows into the armature coils through slip rings. As the armature turns voltage is generated in the field coils. (See Figure 31)

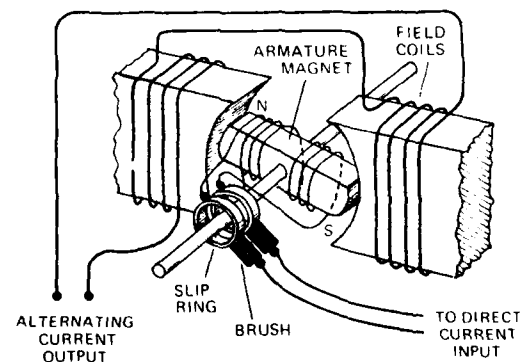


Figure 31

The output of the AC generator is shown in Figure 32.

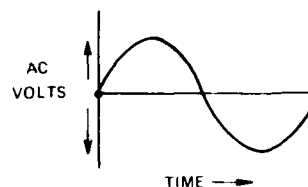


Figure 32

An industrial AC generator has 3 sets of pairs. (See Figure 33) Each pair is independent of the other pairs. The output of each pair (Figure 32) is called a phase. The output of each phase is like Figure 32.

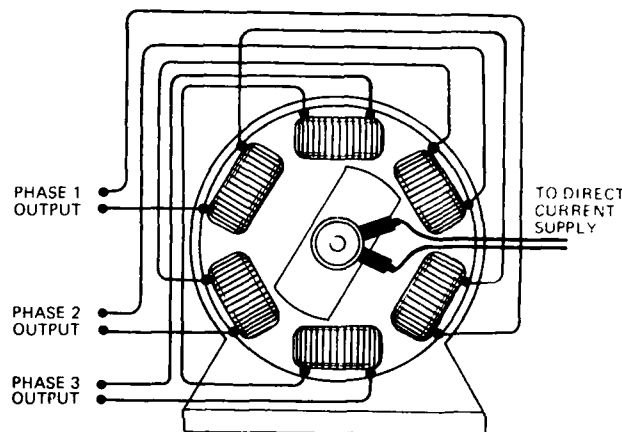


Figure 33

The output of the three phases looks like Figure 34.

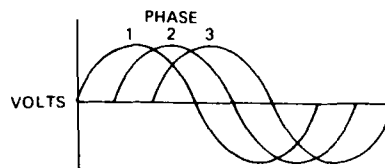


Figure 34

The stronger the magnetic field and the faster the armature rotation, the higher the voltage and current flow.

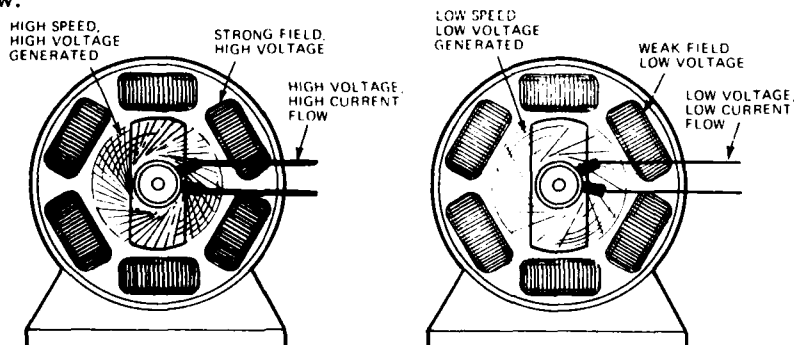


Figure 35

## ALTERNATING CURRENT MOTOR

An alternating current motor has a frame and field coils that are just like those of an alternating current generator (see Figure 33).

The coils of a large alternating current motor would be connected to the corresponding coils of the generator.

The voltage in the generator coils will cause current to flow through the motor coils and create magnetic fields. The fields will change poles successively and create a rotating field inside the motor frame. (See Figures 36A through D)

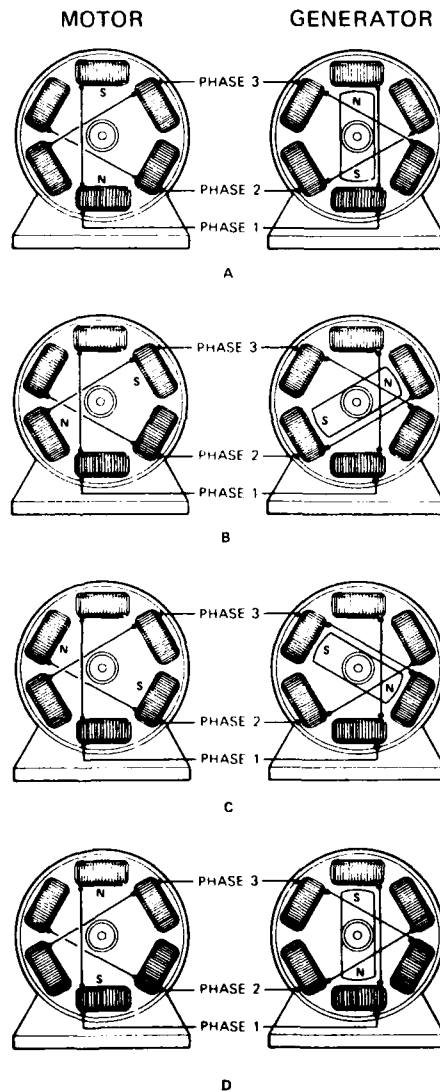


Figure 36



The armature of an alternating current motor is a core with a coil of wire. The ends of the coil are connected together. (See Figure 31)

As the motor field passes over the armature, a voltage is generated (or induced) in the armature coil, and current flows and creates a magnet. The magnet is attracted by the rotating field and rotates with it.

The voltage is induced in the armature coil only if the rotating field rotates faster than the armature does. The difference in armature rotation speed and field rotation speed is called Slip.

The more slip the more voltage is generated, and the stronger the armature magnet becomes. If the magnet is stronger, the motor rotates faster or with more force.

Slip	Armature Voltage Generated	Armature Current Flow	Armature Magnet Strength	Power Output
High	High	High	High	High
Medium	Medium	Medium	Medium	Medium
Low	Low	Low	Low	Low

Now go to the Questions and answer 23 through 32

### HOIST MOTOR SPEED CONTROL

The speed of a mine hoist motor needs to be controlled. The speed of the alternating current motor, like the direct current motor, depends on armature current. In a mine hoist AC motor, armature resistances are placed in the armature coil circuits. The resistances can be bypassed by closing switches. (See Figure 37)

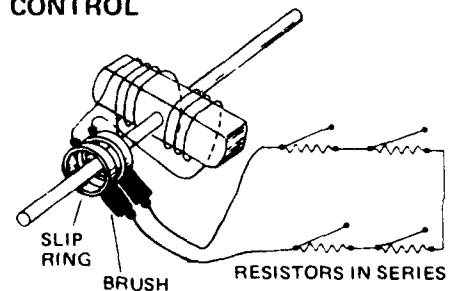


Figure 37

When starting the AC motor, all of the switches are open and the armature circuit has maximum resistance. At this time slip is at a maximum and the generated voltage is high. The high resistance keeps the armature current low. If the resistance were not in the circuit, the armature current might get too high and damage the motor.

As the armature picks up speed, slip, the voltage, and the current flow declines. The switches are closed, one by one, to allow additional current to flow through the armature coils. The armature continues to pick up speed until all of the switches are closed. The motor is then running at its best speed for the amount of work that it is doing.

To slow the armature the switches are opened one by one. This action:

- Increases the resistance of the armature circuit.
- Reduces the flow of current through the armature coils.
- Reduces the strength of the armature magnets.
- Causes the armature to slow down.

In a mine hoist the resistances are normally located in the hoist control room. The switches are in the hoist motor control box and are opened or closed by turning the motor controller. The switches and resistances are connected to the armature coils through slip rings and brushes.

### STARTING DIRECT CURRENT MOTORS

When the armature of a DC motor is turning, a voltage is generated in the armature coil as the coil passes through the motor's magnetic field. This voltage opposes the voltage from the power supply. The voltage causing current to flow in the armature coils is equal to the difference between the power supply voltage and that being generated in the armature coils.

When the armature is not turning all of the power supply voltage is causing current to flow. If the power supply voltage is too high, too much current will flow. Therefore, the voltage first applied to the armature should be low. It is increased slowly as the motor picks up speed and begins to generate the opposing voltage.

The motor is at full speed when the power supply voltage is at its maximum.

The voltage to the armature is increased or decreased by strengthening or weakening the magnetic field of the DC generator, or by changing the output voltage of the rectifier.

Now go to the Questions and answer 33 through 39

.....

### HOIST OPERATION

Figure 38 shows a sample sketch of a mine hoist electrical system with an alternating current motor. It functions as follows:

- Alternating current power comes from the power company to the switch board and through the hoist power switch to the hoist control.
- The hoist control does two things:
  - It sends power to the alternating current motor fields and it
  - controls the amount of resistance in the circuit that includes the armature coils and the resistor sets.
- When the hoist motor starts there is a high resistance in the armature and resistor circuit. The resistance is lowered as the motor picks up speed.

### ALTERNATING CURRENT HOIST MOTOR OPERATION

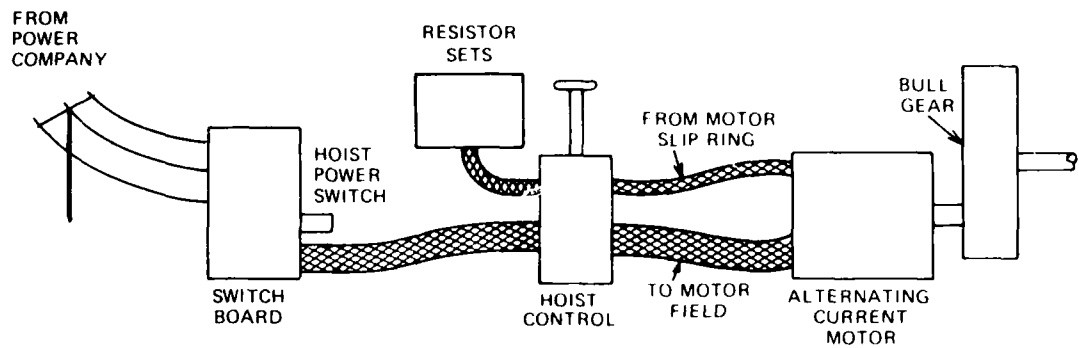


Figure 38

Figure 39 is a simple sketch of a mine hoist electrical system with a direct current hoist motor and a motor generator set. It functions as follows:

- Alternating current power from the power company goes to the switchboard and through the hoist power switch to the alternating current motor of the motor generator set.
- The alternating current motor drives the direct current generator and the exciter generator.

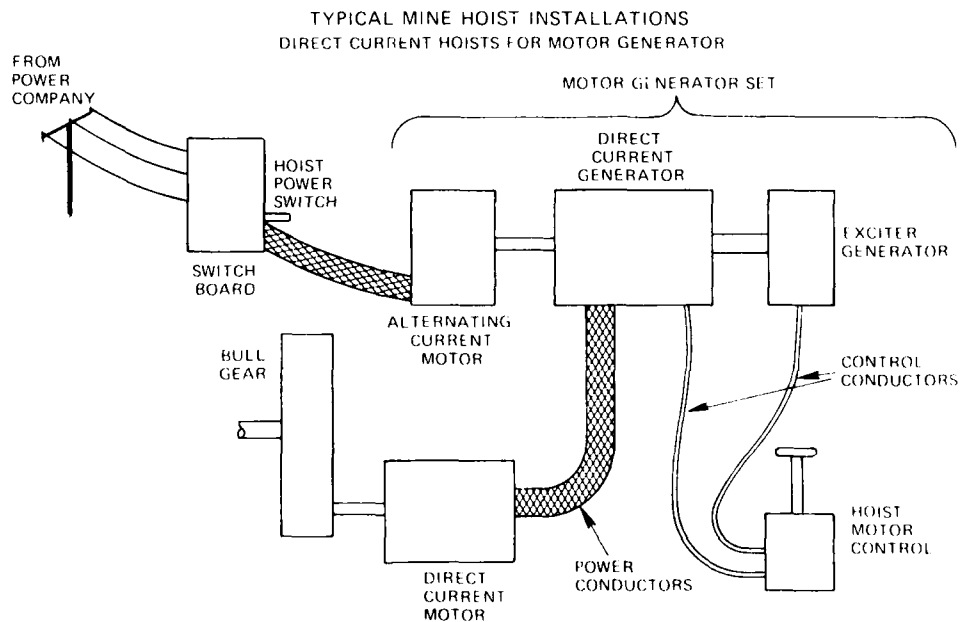


Figure 39

- The exciter generator is a small direct current generator that provides the current for the main generator magnetic fields.
- The output of the exciter generator goes to the hoist motor control then to the direct current generator fields.
- The hoist motor control is a switch that controls the direction and the amount of current that goes to the generator fields.
- The condition of the DC generator fields will determine the direction and amount of current that will be delivered to the hoist motor.
- The output of the main generator drives the hoist motor.

Figure 40 shows a simple sketch of a mine hoist electrical system with a *direct current* motor and a rectifier power supply. It functions as follows:

- Alternating current power goes through the switchboard to the hoist power switch, then to the rectifier.
- The rectifier changes the alternating current to direct current.
- The hoist motor control causes the rectifier to send current at the required voltage and in the proper direction to the hoist motor.

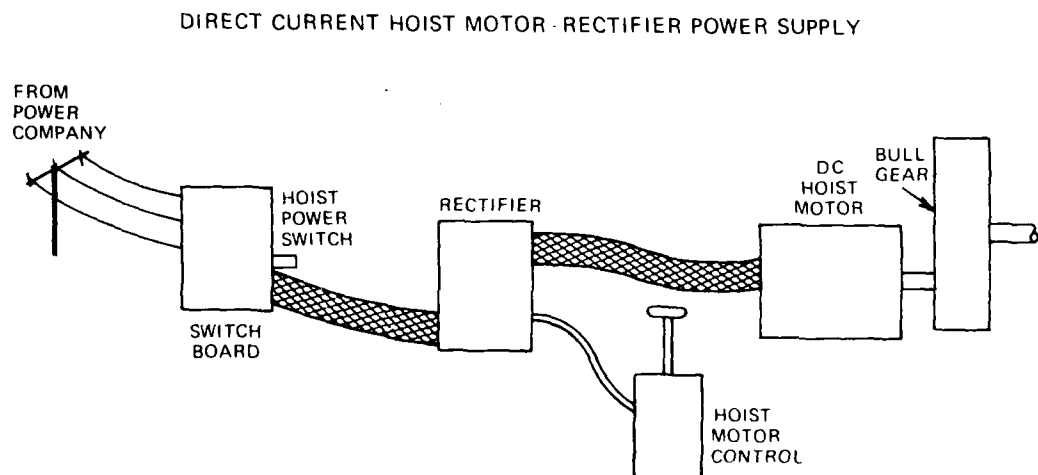


Figure 40

## USING THE MOTOR AS A BRAKE

An electric motor may be used as a brake to control the speed of the machine that it drives. This feature may be used in a mine hoist, for example, to slow the conveyance when lowering a heavy load and when approaching the designated landing.

In a direct current motor the armature voltage is reduced below that of the opposing voltage being generated in the motor armature. The overall voltage then is forcing current to flow out of the motor armature rather than into it. In effect, the motor is now a generator. The energy required to generate the current acts as a brake on the motor armature and causes it to slow. The current that flows back can be sent back to the power company through the motor generator.

In some alternating current motors the motor is simply reversed. When lowering, for example, the hoist motor control is placed in the hoist position. The rotating field starts to rotate in the opposite direction and will slow the rotation speed of the armature.

In other alternating current motors, a switch is provided to substitute direct current for alternating current in one or two of the phases. Voltage is then generated in the armature coils as they rotate in the newly created magnetic field. The voltage is absorbed in the starting resistances. The energy thus absorbed acts as a brake on the motor armature.

The use of the motor as a brake is sometimes referred to as dynamic braking.

## ELECTRICAL SAFETY

Electricity can be dangerous if not properly controlled.

If electrical machinery is used near flammable materials, vapors, or gases, sparks may be given off and cause a fire.

If the current flowing through a conductor is greater than the conductor can carry safely, the conductor may overheat and cause a fire or otherwise damage the machines.

If just 1/100 of an ampere passes through your body the shock could kill you.

Federal safety regulations require that steps be taken to prevent such accidents. Basic requirements (see Figure 41), are as follows:

Electrical machinery that is used in mines and other areas where flammable dust, gas, or vapors may be present must be sealed. This will prevent sparks, such as occur on motor commutators, switches, and at loose connections, from igniting the flammable materials.

Every electrical circuit must use conductors that are large enough to carry the normal current flow of the circuit, plus an acceptable overload without overheating. For most circuits a 25% overload is allowed. The circuit must also have a fuse or circuit breaker (automatic switch) that will interrupt the current flow if the normal load plus the overload is exceeded.

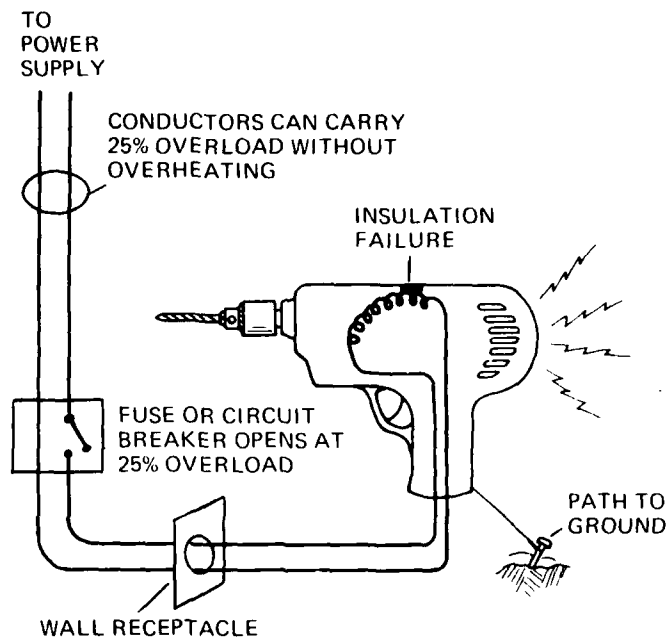


Figure 41

Conductors and other current-carrying parts of the machines shall be insulated or enclosed. Exposed metal parts of electrical machinery that do not carry current normally, the frames, stands, enclosures, must be connected to the ground. Normally the conductors and parts of electrical machines through which the current flows are insulated from the frames and other structural parts of the machines. If the insulation is damaged these parts may carry current. If a person touches one of the current carrying parts, his (her) body will provide a path for the current to flow to the ground. The person will receive a shock and may be killed. The ground connection provides a path for current to flow to the ground. Thus, if a break occurs in the insulation, current will flow to ground in sufficient quantity to open the overcurrent protection device.

Now go to the Questions and answer 40 through 43

### PRACTICE QUESTIONS FOR THE ELECTRICAL SYSTEM

1. Electricity flows from the power supply to the equipment that it operates through \_\_\_\_\_.
2. The pressure that causes the electric current to flow is called \_\_\_\_\_.
3. The flow of current is measured in \_\_\_\_\_.
4. In an electrical system the amount of power, light, or heat generated increases if the voltage and/or current flow \_\_\_\_\_.
5. In an electrical system the flow of current can be stopped or started by a \_\_\_\_\_.
6. If the voltage in a circuit is fixed, the flow of current can be changed by changing the \_\_\_\_\_ of the circuit.
7. Electrical conductors and equipment are damaged by too much \_\_\_\_\_ and/or \_\_\_\_\_.
8. Voltage is measured with a \_\_\_\_\_; current flow is measured with an \_\_\_\_\_.
9. With direct current electricity the voltage causes current to flow in \_\_\_\_\_ direction.
10. If the current flows one way then the other way, it is called \_\_\_\_\_.
11. A \_\_\_\_\_ or \_\_\_\_\_ must be used to run direct current machines with a commercial alternating current power supply.

### NOW CONTINUE WITH ELECTRICITY AND MAGNETISM

12. Direct current electricity flowing through a wire coil wrapped around an iron core will cause the iron core to become a \_\_\_\_\_.
13. The upper pole of an electromagnet is a North pole; if we reverse the direction of current flow in the coil the upper pole will be a \_\_\_\_\_ pole.
14. Like poles \_\_\_\_\_ each other; unlike poles \_\_\_\_\_ each other.
15. A wire passing through a magnetic field has a voltage generated that will cause current to flow from right to left. If we reverse the direction of motion of the wire and reverse the positions of the North and South poles, the generated voltage will cause current to flow from \_\_\_\_\_ to \_\_\_\_\_.

16. When a wire passes through a magnetic field the voltage is \_\_\_\_\_ as the wire enters the field; the voltage is at a \_\_\_\_\_ at the center of the field; the voltage is \_\_\_\_\_ as it leaves the field.

**NOW CONTINUE WITH ELECTRIC MOTORS AND GENERATORS**

17. An electric motor changes electrical energy into \_\_\_\_\_; a generator changes \_\_\_\_\_ into electrical energy.

18. List the four principal parts of a direct current electric motor.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

19. An electric motor operates on these principles;

Reversing the flow of current through the coil of an electromagnet \_\_\_\_\_  
the poles of the magnet.

Opposite poles \_\_\_\_\_ each other.

Like poles \_\_\_\_\_ each other.

20. When the brushes of a direct current motor change commutator segments the \_\_\_\_\_  
\_\_\_\_\_ in the armature coil is \_\_\_\_\_.

21. Increasing the armature current \_\_\_\_\_ the magnetic forces which \_\_\_\_\_  
the armature.

22. Power output of the motor is \_\_\_\_\_ by decreasing the armature current.

**NOW CONTINUE WITH DIRECT CURRENT GENERATORS**

23. In a direct current generator, direct current from an outside source flows through the  
\_\_\_\_\_.

24. The voltage generated in a direct current generator increases as the \_\_\_\_\_ of  
the field and \_\_\_\_\_ of the armature increases.



25. In a direct current generator the current generated in the armature coil is changed from \_\_\_\_\_ current to \_\_\_\_\_ current as it passes through the \_\_\_\_\_.
26. In an alternating current generator direct current flows into the \_\_\_\_\_ coils; alternating current is generated in the \_\_\_\_\_ coils.
27. The output voltage from each pair of field coils is called a \_\_\_\_\_. Each \_\_\_\_\_ is independent of the other two phases.
28. In an alternating current motor a \_\_\_\_\_ magnetic field is created within the motor frame.
29. The ends of the armature coils of an alternating current motor are \_\_\_\_\_.
30. The current flow through the armature coils of an alternating current motor is caused by an \_\_\_\_\_ voltage.
31. Slip is the difference between the speed of rotation of the \_\_\_\_\_ and the \_\_\_\_\_.
32. An alternating current motor has a high power output when the slip is \_\_\_\_\_.

#### **NOW CONTINUE WITH HOIST MOTOR SPEED CONTROL**

33. The speed of direct current motors and alternating current motors is controlled by changing the current flow in the \_\_\_\_\_.
34. The resistors and switches in the armature circuit of an alternating current motor are used to control \_\_\_\_\_ in the armature coil.
35. The resistance in the armature coil circuit of an alternating current motor is least when the armature rotates at \_\_\_\_\_ speed.
36. Applying full voltage to a direct current motor armature that is stopped can \_\_\_\_\_.

37. The voltage that causes current to flow in a direct current motor armature is equal to the power supply voltage \_\_\_\_\_ the voltage generated in the armature.

38. If the hoist motor is powered by a motor generator set the motor control adjusts the \_\_\_\_\_ in the generator field.

**NOW CONTINUE WITH USING THE MOTOR AS A BRAKE**

39. To use a direct current motor as a brake the voltage to the motor armature is \_\_\_\_\_.

40. One method of using an alternating current motor as a brake is to \_\_\_\_\_ the rotating field.

41. A second method of using an alternating current motor as a brake is to substitute \_\_\_\_\_ in one or two of the phases.

42. In what three ways can electricity be dangerous?

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43. What do safety regulations require to prevent such accidents?

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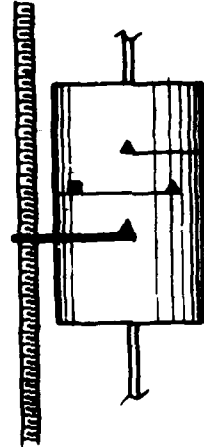
## ANSWERS FOR THE PRACTICE QUESTIONS

1. conductors
2. voltage
3. amperes
4. increases
5. switch
6. resistance
7. voltage, current
8. voltmeter, ammeter
9. one
10. alternating current
11. rectifier or motor generator
12. magnet
13. South
14. repel; attract
15. right; left
16. low; peak; low
17. rotary motion; rotary motion
18. brushes; armature; commutator; field magnets
19. reverses; attract; repel
20. current flow or voltage; reversed
21. increases; rotate
22. decreased
23. magnetic field coils
24. strength; speed
25. alternating; direct; commutator
26. armature; field
27. phase; phase
28. rotating
29. connected together
30. induced
31. rotating field; armature
32. high
33. armature
34. current flow
35. high
36. cause damage
37. less
38. current flow
39. reduced
40. reverse
41. direct current
42. shock or kill people; ignite materials; cause overheating
43. connecting exposed parts to the ground; enclosing electrical machines; provide fuses or circuit breakers.

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 12

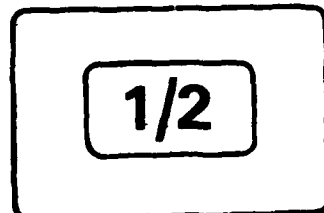
### DEPTH INDICATOR



#### OBJECTIVE

The trainee will know the operating principles  
of the depth indicator

#### TIME



## **INSTRUCTIONAL OBJECTIVES FOR DEPTH INDICATOR**

The trainee will be able to answer in writing multiple-choice questions concerning the function (use) of the depth indicator.

The trainee will be able to identify each type of depth indicator.

Given illustrations of a dial depth indicator and a cylindrical depth indicator, the trainee will be able to label in writing each type.

The trainee will be able to describe the operating principles of the depth indicator.

The trainee will be able to answer in writing multiple-choice questions about how each indicator works.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for the depth indicator.

## DEPTH INDICATOR

The depth indicator shows the vertical position of the conveyance in the shaft.

The depth indicator may be in the form of a dial or a cylinder.

### Dial Depth Indicator

Figure 1 shows a dial indicator. The arrow is geared to the drum and moves around the dial. The position of the dump or collar and each working level is indicated on the dial. When the arrow points to a position, the conveyance is at that position.

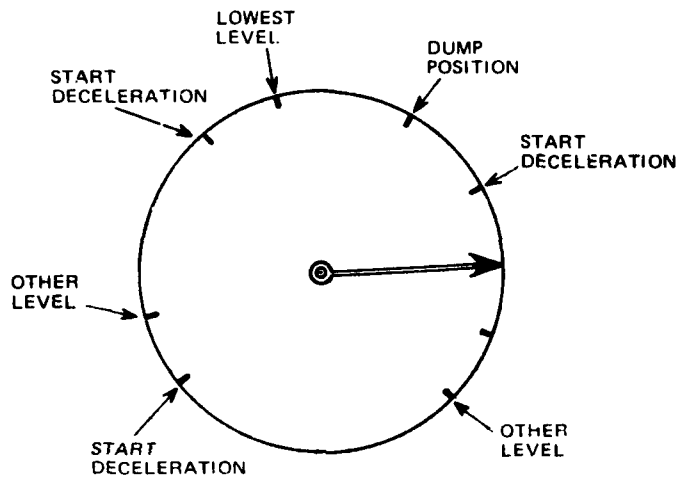


Figure 1

Usually the experienced noist operator will add other marks at each stopping point to show where he/she must decelerate in order to slow in time to make a smooth stop.

He/she may also make other marks if the stopping point changes because of a heavier load.

### Cylinder Depth Indicator

The cylindrical depth indicator is shown in Figure 2.

The threaded shaft and the cylinder rotate with the hoist drum.

The indicator moves up and down on the threaded shaft as the conveyance moves up and down the mine shaft.

A point on the cylinder's surface passes under the end of the indicator when the conveyance is at a specific depth.

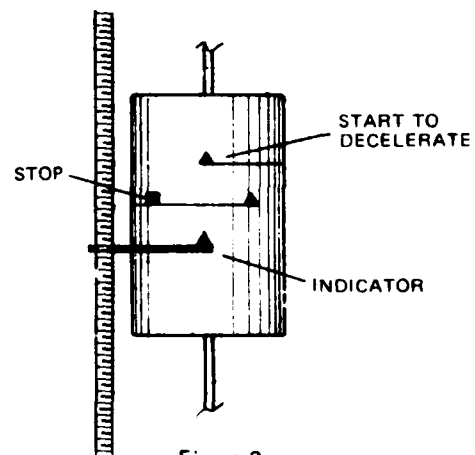


Figure 2

The hoist operator marks the points on the cylinder that correspond to the dump level, working level(s), collar and other significant points in the mine shaft. He/she may also mark points where the conveyance should decelerate, or reach cruise speed, and other points where operator action is required.

#### **Marks on Drum**

Experienced operators may also mark the flange of the drum to provide a more accurate and easily read indication of the position of the conveyance.

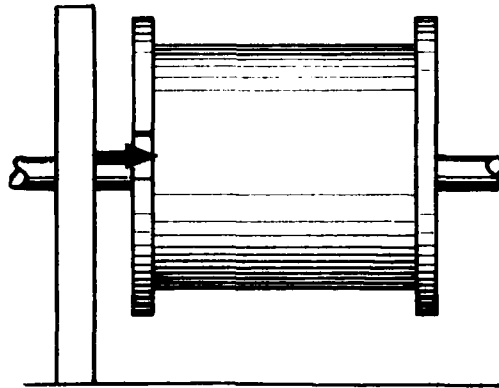


Figure 3

#### **FEDERAL REGULATIONS (From Title 30 CFR)**

##### **Metal and Nonmetallic**

57.19-9 *Mandatory.* An accurate and reliable indicator of the position of the cage, skip, bucket, or cars in the shaft shall be provided.

##### **Coal Mines**

75.1401 An accurate and reliable indicator of the position of the cage, platform, skip, bucket, or cars shall be provided.

##### **75.1401-3 HOISTS; INDICATORS**

The indicator required by 17.1401 shall be placed so that it is in clear view of the hoisting engineer and shall be checked daily to determine its accuracy.

## PRACTICE QUESTIONS FOR DEPTH INDICATOR

Complete these sentences with the best answer:

1. The depth indicator shows the \_\_\_\_\_ of the conveyance in the shaft.
2. The arrow of a dial depth indicator is geared to the \_\_\_\_\_ and moves around the \_\_\_\_\_.
3. The position of the \_\_\_\_\_ is indicated on the dial.
4. The hoist operator knows when the conveyance is at a certain level because the arrow on the dial \_\_\_\_\_.
5. The indicator of a cylindrical depth indicator moves up and down on the threaded shaft as the conveyance \_\_\_\_\_.
6. The hoist operator knows when the conveyance is at a certain level because the indicator for the cylinder \_\_\_\_\_.
7. A more accurate and easily read indication of the conveyance position may be provided by marking the \_\_\_\_\_ of the drum.

## FEDERAL REGULATIONS

### Metal and Nonmetallic Mines

8. An accurate and reliable indicator of \_\_\_\_\_ in the shaft shall be provided.

### Coal Mines

9. An accurate and reliable indicator of \_\_\_\_\_ shall be provided.
10. This indicator shall be placed so that it is in clear view of the \_\_\_\_\_.
11. This indicator shall be checked \_\_\_\_\_ to determine its accuracy.



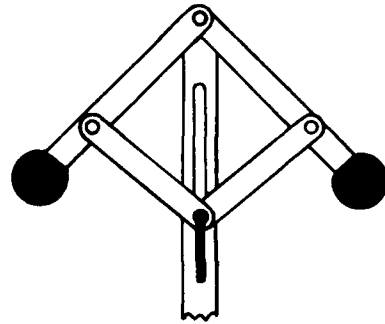
## ANSWERS TO DEPTH INDICATOR PRACTICE QUESTIONS

1. vertical position
2. drum; dial.
3. dump or collar and each working level
4. points to that position.
5. moves up and down the mine shaft.
6. stops over the mark for that position.
7. flanges
8. the position of the cage, skip, bucket, or cars
9. the position of the cage, platform, skip, bucket or cars
10. hoisting engineer.
11. daily

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 13

### SAFETY CONTROLLER



### OBJECTIVE

The trainee will know the major components and operating principles for the safety controller.

### TIME

1/2

## INSTRUCTIONAL OBJECTIVES FOR SAFETY CONTROLLER

The trainee will be able to answer in writing multiple-choice questions concerning the function (use) of the safety controller.

The trainee will be able to identify the parts of a safety controller.

Given illustrations of the governor and the depth indicator, the trainee will be able to label each.

The trainee will be able to explain the operating principles of a safety controller.

The trainee will be able to answer multiple choice questions about the operating principles of the safety controller.

## SAFETY CONTROLLER

The Lilly, Simplex or other automatic controller is a multi-purpose safety device synchronized with the movement of the drum shaft. The basic controller prevents overspeed and overtravel, and also applies the brake of an electric hoist in case of power failure.

The controller consists of:

- A governor which prevents overspeed. (See Figure 1)

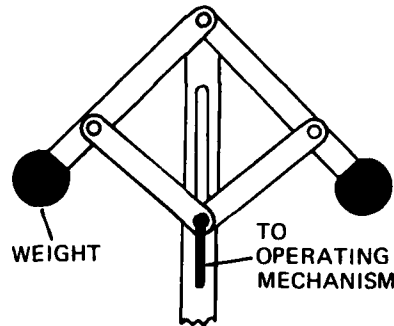


Figure 1

Safe operation of the hoist requires that the conveyance starts moving at slow speed, accelerates to cruising speed, then decelerates to a stop at the destination.

If the drum overspeeds, the weights of the governor will move outward due to centrifugal force and through linkages, cut off power to the hoist motor and set the brake.

- A depth indicator with overtravel switches. (See Figure 2) This is in addition to the depth indicator discussed in Unit 12, "Depth Indicator."

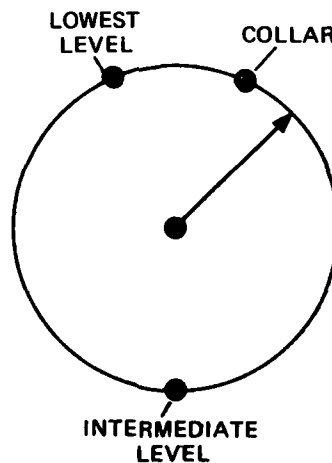


Figure 2

If the conveyance travels too far above the dump position or too far below the lowest working level, power will be cut off from the hoist motor automatically.

The controller is designed to permit only low conveyance speed in the acceleration and deceleration stages, and higher speed only in the cruising stage. Most controllers sound warning bells or buzzers as the conveyance leaves the cruising stage and enters the deceleration stage.

The basic controller is described in this unit. Many mines may have controllers with additional features not described here.

### PRACTICE QUESTIONS FOR SAFETY CONTROLLER

Complete these sentences with the correct answers.

1. The Lilly, Simplex or other safety controller is a multi-purpose safety device synchronized with \_\_\_\_\_.
2. The basic controller prevents \_\_\_\_\_ and also applies the \_\_\_\_\_ of an electric hoist in case of power failure.
3. The weights of the governor move outward if the drum \_\_\_\_\_. The power to the hoist motor is cut off and the brake is \_\_\_\_\_.
4. The depth indicator has \_\_\_\_\_ switches. Power to the hoist motor is cut automatically if \_\_\_\_\_.
5. The controller permits only low conveyance speed in the acceleration and deceleration stages; higher speed is permitted only in the \_\_\_\_\_.

### ANSWERS TO PRACTICE QUESTIONS

1. the movement of the drum shaft.
2. overspeed and overtravel; brake
3. overspeeds. set.
4. overtravel; the conveyance travels too far above the dump position or too far below the lowest working level.
5. cruising stage.

## INSTRUCTIONAL OBJECTIVES FOR THE HOIST CONTROL PANEL

The trainee will be able to answer "fill-in-the-blank" questions concerning the function (use) of the hoist controls and indicators.

The trainee will be able to identify the hoist controls and indicators.

1. Given illustrations of hoist controls and indicators, where each part is labeled with a letter, the trainee will be able to write the name of each lettered part.
2. The trainee will be able to answer in writing multiple-choice questions concerning the hoist controls and indicators.

The trainee will be able to label in writing the types of control panels: single drum hoist, double drum, single clutch hoist, and a double drum, double clutch hoist.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for the hoist panel.



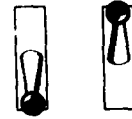
## HOIST CONTROL PANEL

The hoist controls and indicators are grouped together on a control panel within easy reach or sight of the hoist operator's position.

The controls may be set of levers, handles or pushbuttons or switches.

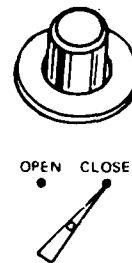
The levers are used for:

- Hoist motor control
- Hydraulic or mechanical brake control
- Clutch control
- Electric brakes



Pushbuttons or switches are used to:

- Control the communication systems
- Override the slack rope, overtravel, deadman, and similar safety switches
- Operate the main power switch
- Place the hoist in manual or automatic operation
- Start and stop accessories such as the hydraulic system, air compressor, or lubricating oil pump.



The indicators may be lights, meters and dials.

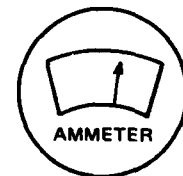
Light indicators show the condition of the hoist components and of other vital mine machinery. These lights may indicate:

- Operating method of the hoist— manual or automatic
- Condition of bypass switch
- Clutches engaged or disengaged
- Safety gates opened or closed
- Precise position of the skip in the loading or dump area
- Warning of low lubrication oil pressure, low hydraulic or air pressure, or ventilation or flood control machines not operating
- Various equipments running or stopped.

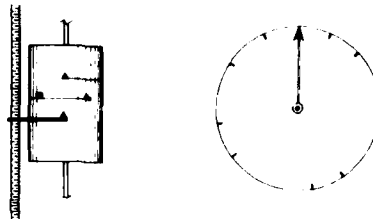


Meters may indicate:

- Lubrication oil, air, or hydraulic pressure
- Current flow or voltage
- Rope speed



The depth indicator, which shows the position of the conveyance, may be a dial or cylindrical indicator.



The controls and indicators are grouped around or on the control stand. The levers may be mounted on the stand or on the floor near the stand. Figures 1, 2 and 3 are examples of the arrangement of hoist controls for single drum hoists, double drum hoists with a single clutch, and double drum hoists with two clutches. The controls for the hoist you will operate may have a different arrangement than those shown. The basic controls and indicators, however, will be similar.

### Single Drum Hoist

The control panel in Figure 1 is for a single drum hoist.

The brakes are set when the control handle is pulled back and released when it is pushed forward.

The rope on an overwound drum will be lowered when the motor control is pushed forward and raised when the motor control is pulled back.

Electric braking can be done by reversing the motion of the control, that is, pulling the motor control lever back if lowering, and pushing it forward if hoisting.

If the hoist has an AC motor with dynamic braking, an additional switch and lever are provided to control the braking.

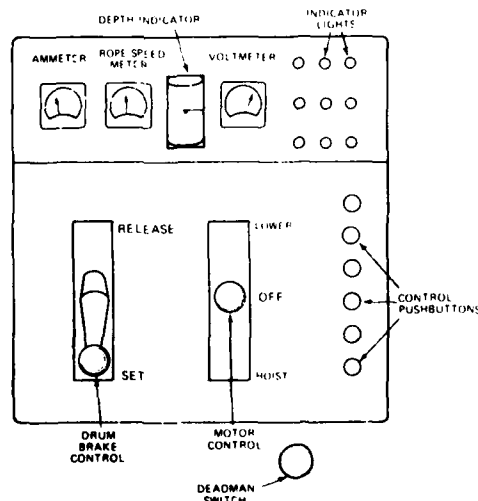


Figure 1

### Double Drum, Single Clutch Hoist

The control panel in Figure 2 is for a double drum hoist with a clutch on the left drum only.

The clutch and left drum brake are controlled by the same lever. The clutch is engaged when the lever is pulled to the right and disengaged when it is pulled to the left. The left drum brake must be applied in order to get the clutch operating lever in the disengaged position.

Some control stands have separate operating levers for the clutch and brake. The levers are interlocked, however, to prevent disengaging the clutch when the drum brake is not applied.

Some double drum hoists do not have a clutch and will have only one brake operating lever.

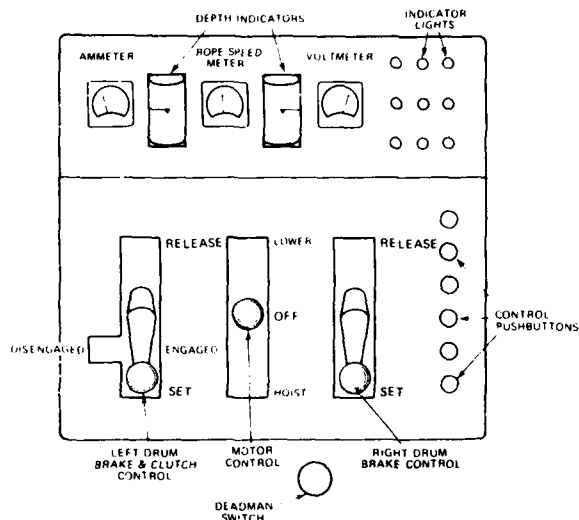


Figure 2

### Double Drum, Double Clutch Hoist

The control panel in Figure 3 is for a double drum, double clutch hoist.

The clutches are interlocked with the brakes just the same as in the double drum, single clutch hoist.

Either drum can be operated as a single drum hoist.

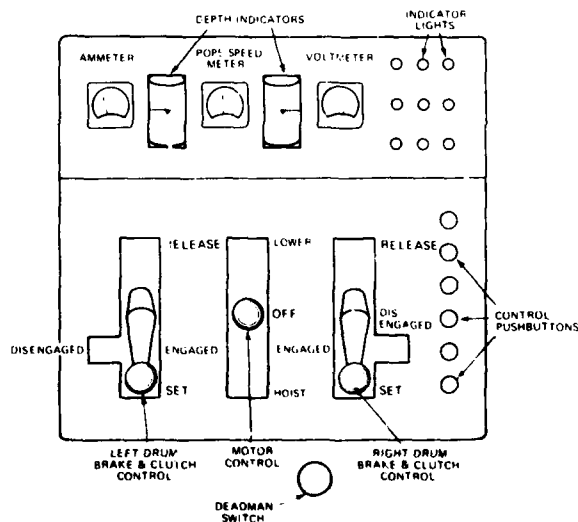


Figure 3

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic**

57.19-9 *Mandatory.* An accurate and reliable indicator of the position of the cage, skip, bucket, or cars in the shaft shall be provided.

57.19-10 *Mandatory.* Hoist controls shall be placed or housed so that noise from machinery or other sources will not prevent hoistmen from hearing signals.

### **Underground Coal Mines**

75.1401 An accurate and reliable indicator of the position of the cage, platform, skip, bucket, or cars shall be provided.

75.1401-3 The indicator required by 75.1401 shall be placed so that it is in clear view of the hoisting engineer and shall be checked daily to determine its accuracy.

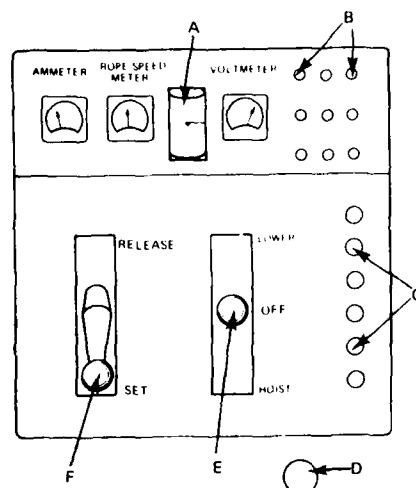
## PRACTICE QUESTIONS FOR THE HOIST CONTROL PANEL

Complete these sentences with the correct answers:

1. The hoist controls and indicators are on a \_\_\_\_\_ within sight or easy reach of the \_\_\_\_\_.
2. The levers of the hoist control are used for \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.
3. Pushbuttons or switches are used to:
  - A. Control the \_\_\_\_\_.
  - B. Override the slack rope, \_\_\_\_\_ safety switches.
  - C. Operate the \_\_\_\_\_.
  - D. Place the hoist in \_\_\_\_\_ operation.
  - E. Start and stop accessories such as the \_\_\_\_\_, air compressor or \_\_\_\_\_.
4. Indicators may be \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_.
5. Light indicators may show:
  - A. Operating method of the hoist — \_\_\_\_\_ or \_\_\_\_\_.
  - B. Condition of bypass \_\_\_\_\_.
  - C. Clutches \_\_\_\_\_ or \_\_\_\_\_.
  - D. Safety gates \_\_\_\_\_ or \_\_\_\_\_.
  - E. Precise position of the skip in the \_\_\_\_\_ or \_\_\_\_\_ area.
  - F. Warning of low \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_ pressure or \_\_\_\_\_ or flood control machines not working.
  - G. Various equipment \_\_\_\_\_.
6. Meters may indicate:
  - A. \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_ pressure.
  - B. \_\_\_\_\_ flow or voltage.
  - C. \_\_\_\_\_ speed.

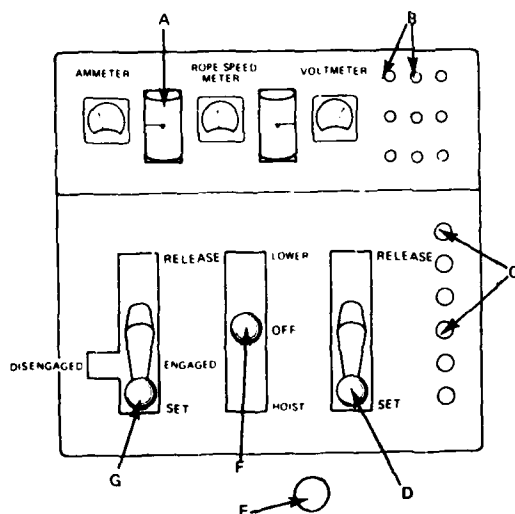
7. Depth indicators show the position of the \_\_\_\_\_.

8. Below is an illustration of a control panel for a single drum hoist. Label each arrowed part.



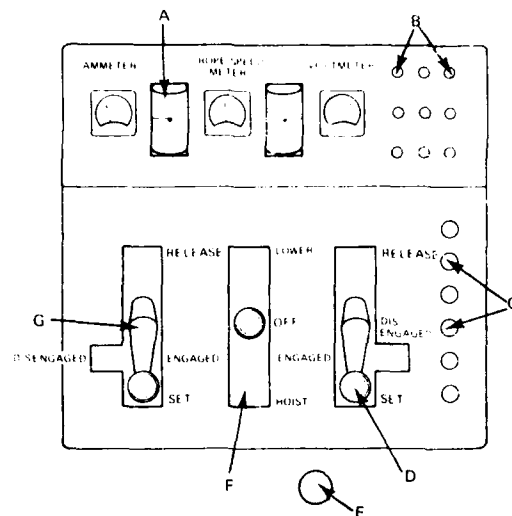
- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_
- E. \_\_\_\_\_
- F. \_\_\_\_\_

9. Below is an illustration of a control panel for a double drum, single clutch hoist. Label each arrowed part.



- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_
- E. \_\_\_\_\_
- F. \_\_\_\_\_
- G. \_\_\_\_\_

10. Below is an illustration of a control panel for a double drum, double clutch hoist.  
Label each arrowed part.



- A. \_\_\_\_\_  
B. \_\_\_\_\_  
C. \_\_\_\_\_  
D. \_\_\_\_\_  
E. \_\_\_\_\_  
F. \_\_\_\_\_  
G. \_\_\_\_\_

#### Metal and Nonmetallic

11. An accurate and reliable \_\_\_\_\_ of the position of the cage, skip, \_\_\_\_\_ or cars in the shaft shall be provided.
12. Hoist controls shall be placed or housed so that noise from machinery or other sources will not \_\_\_\_\_.

#### Underground Coal Mines

13. An accurate and reliable \_\_\_\_\_ of the position of the \_\_\_\_\_, platform, skip, bucket or \_\_\_\_\_ shall be provided.
14. The indicator shall be placed \_\_\_\_\_ and shall be checked \_\_\_\_\_ to determine its accuracy.

## ANSWERS TO CONTROL PANEL PRACTICE QUESTIONS

1. control panel; hoist operator.
2. hoist motor control; hydraulic or mechanical brake control; clutch control; electric brakes.
3.
  - A. communication systems
  - B. overtravel, deadman, and similar
  - C. main power switch
  - D. manual or automatic
  - E. hydraulic system; lubricating oil pump.
4. lights; meters; dials.
5.
  - A. manual; automatic
  - B. switches
  - C. engaged; disengaged
  - D. open; closed
  - E. loading; dumping
  - F. lubrication; hydraulic; air; ventilation
  - G. running or stopped
6.
  - A. Lubrication oil; air; hydraulic
  - B. Current
  - C. Rope
7. conveyance.
8.
  - A. Depth indicator
  - B. Indicator lights
  - C. Control pushbuttons
  - D. Deadman switch
  - E. Hoist motor control
  - F. Drum brake and clutch control
9.
  - A. Depth indicator
  - B. Indicator lights
  - C. Control pushbuttons
  - D. Right drum and brake
  - E. Deadman switch
  - F. Hoist motor control
  - G. Left drum brake and clutch control

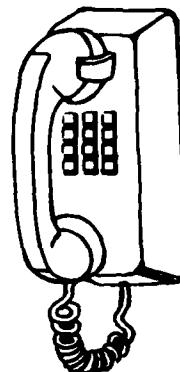


10.
  - A. Depth indicator
  - B. Indicator lights
  - C. Control pushbutton
  - D. Right drum brake and clutch control
  - E. Deadman switch
  - F. Motor control
  - G. Left drum brake and clutch control
11. indicator; bucket
12. prevent hoistmen from hearing signals.
13. indicator; cage; cars
14. in clear view of the hoisting engineer; daily

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 15**

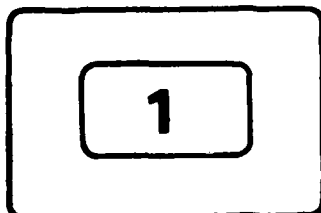
# **COMMUNICATION SYSTEMS**



## **OBJECTIVE**

**The trainee will know the communication systems  
and the federal regulations for these systems**

## **TIME**



## INSTRUCTIONAL OBJECTIVES FOR COMMUNICATION SYSTEMS

The trainee will be able to answer in writing multiple-choice questions concerning the function (use) of the communication systems.

The trainee will be able to describe the uses of different communication systems.

Given a list of the communication systems where each system is lettered, and a list of the uses of these communication systems, the trainee will be able to match each system to its use.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for communication systems.

## COMMUNICATION SYSTEMS

Communication systems provide the means of transferring information from one location to another.

### Types of information to be transferred:

#### Direct orders or requests—

The skip tender may request that the skip be lowered to his/her working level.

#### Explanation of orders or requests—

The skip tender may need the conveyance for a special purpose or precede or follow-up his/her request with an explanation.

#### Information that indicates the condition of equipment or of the mine environment—

The skip tender may need to inform the supervisor at the surface of the presence of a breakdown of the loader.

### Types of communication systems:

Hoist bell  
Telephone  
High frequency radio  
Public address system  
Indicator lights  
Meters and/or gauges  
Closed-circuit TV

### Use of each communication system:

The Hoist Bell is used to request or order the movement of the conveyance. For example, the skip tender, using a series of bells, will signal a request for the conveyance to be brought to his/her level.



The Telephone or Radio is used for longer messages. For example, the hoist operator may tell the skip tender that the conveyance will not be available for a time. Therefore, the answer to the request will be delayed.



The Public Address system is used to pass information to many people over a wide area. For example, it may be used to give a general announcement or to issue a warning in case of an emergency.



Indicator Lights are normally used to communicate that a malfunction has occurred, that power is on or off, or that a machine is operating. For example, in some mines an indicator light in the hoist room will show that the pumps are running.



Meters and Gauges communicate conditions. For example, the ammeter indicates the load on the motor, the rope meter shows the speed of the rope, and the temperature gauges show temperatures in the mine.



Closed Circuit TV provides a view of likely problem areas. The hoist operator is able to observe areas such as the loading pockets and the dumping area.



The specific use of a communication system varies from one mine to another. For example, in some mines the skip tender will telephone the hoist operator before giving a bell signal requesting the use of the hoist.

It is a safe practice for the hoist operator to acknowledge the bell signal prior to answering the request.

In general, basic bell codes are standard, but there are many variations among mines.

The mine hoist operator must be thoroughly familiar with the operating procedures for the communication systems of his/her mine.

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic**

#### **SIGNALING**

**57.19-90 Mandatory.** There shall be at least two effective approved methods of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

**57.19-91 Mandatory.** Hoist operators shall accept hoisting instructions only by the regular signaling system unless it is out of order. In such an event, and during other emergencies, the hoist operator shall accept instructions to direct movement of the conveyances only from authorized persons.

**57.19-92 Mandatory.** A method shall be provided to signal the hoist operator from cages or other conveyances at any point in the shaft.

**57.19-93 Mandatory.** A standard code of hoisting signals shall be adopted and used at each mine. The movement of a shaft conveyance on a "one bell" signal shall be prohibited.

**57.19-94 Mandatory.** A legible signal code shall be posted prominently in the hoist house within easy view of the hoistmen, and at each place where signals are given or received.

**57.19-96 Mandatory.** Any person responsible for receiving or giving signals for cages, skips, and mantrips when men or materials are being transported shall be familiar with the posted signaling code.

### **Underground Coal Mines**

75.1402. There shall be at least two effective methods approved by the Secretary of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

75.1402-1. One of the methods used to communicate between shaft stations and the hoist room shall give signals which can be heard by the hoisting engineer at all times while men are underground.

75.1402-2. Signaling systems used for communication between shaft stations and the hoist room shall be tested daily.

## PRACTICE QUESTIONS FOR COMMUNICATION SYSTEMS

Complete these sentences with the correct answers:

1. Communication systems allow information to be \_\_\_\_\_.
2. The types of information to be transferred may be \_\_\_\_\_ or \_\_\_\_\_ ;  
an explanation of \_\_\_\_\_ or \_\_\_\_\_ ; indications of the condition of \_\_\_\_\_  
or of the mine \_\_\_\_\_.

Fill in the blank with the correct type of communication system.

3. When the hoist operator wants a view of a problem area somewhere in the mine, he/she  
will use \_\_\_\_\_.
4. If the hoist operator needs to pass information to many people over a wide area, he/she  
will use \_\_\_\_\_.
5. The hoist operator finds out the condition of the mine environment or of the equipment  
by using \_\_\_\_\_.
6. If a long message is to be sent, the hoist operator will use \_\_\_\_\_ or \_\_\_\_\_.
7. \_\_\_\_\_ show that a malfunction has occurred, power is on or off, or  
that a machine is operating.
8. \_\_\_\_\_ is used to request or order the movement of the conveyance.

Complete these sentences with the correct answers:

### Metal and Nonmetallic Mines

9. There shall be at least two effective approved methods of signaling between each of  
the shaft stations and the \_\_\_\_\_, one of which shall be a \_\_\_\_\_ or  
\_\_\_\_\_.
10. Hoist operators shall accept hoisting instructions only by the regular signaling system  
unless \_\_\_\_\_.
11. When the regular signaling system is out of order, and during other emergencies, the  
hoist operator shall accept instructions to direct movement of the conveyances only  
from \_\_\_\_\_.

12. A method shall be provided to signal the hoist operator from \_\_\_\_\_ or \_\_\_\_\_  
\_\_\_\_\_ at any point in the \_\_\_\_\_.
13. A standard code of hoisting signals shall be \_\_\_\_\_ and \_\_\_\_\_ at each mine.  
The movement of a shaft conveyance on a "one bell" signal shall be \_\_\_\_\_.
14. A legible \_\_\_\_\_ shall be posted prominently in the hoist house within easy  
view of the hoistmen, and at each place where \_\_\_\_\_.
15. Any person responsible for receiving or giving signals for cages, skips, and mantrips when  
men or materials are being transported shall be familiar with \_\_\_\_\_.

#### **Underground Coal Mines**

16. There shall be at least two effective methods approved by the secretary of signaling  
between each of the \_\_\_\_\_ and the \_\_\_\_\_, one of which shall be  
a \_\_\_\_\_ or \_\_\_\_\_.
17. One of the methods used to communicate between shaft stations and the hoist room  
shall give signals which can be heard by \_\_\_\_\_ while  
men are \_\_\_\_\_.
18. Signaling systems used for communication between shaft stations and the hoist room  
shall be tested \_\_\_\_\_.



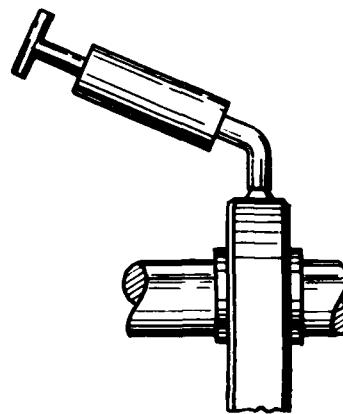
## ANSWERS TO COMMUNICATION SYSTEMS PRACTICE QUESTIONS

1. transferred from one location to another.
2. direct orders; requests; orders; requests; equipment; environment.
3. closed circuit T.V.
4. public address.
5. meters and gauges.
6. telephone; radio.
7. Indicator lights
8. Hoist bell
9. hoist room; telephone; speaking tube.
10. it is out of order.
11. authorized persons
12. cages; other conveyances; shaft.
13. adopted; used; prohibited.
14. signal code; signals are given or received.
15. the posted signaling code.
16. shaft stations; hoist room; telephone; speaking tube.
17. the hoisting engineer at all times; underground.
18. daily.

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 16

# LUBRICATION



## OBJECTIVE

The trainee will know the methods,  
components and federal regulations  
for lubrication

## TIME

1

## INSTRUCTIONAL OBJECTIVES FOR LUBRICATION

The trainee will be able to write in one or two sentences the function (use) of lubrication.

The trainee will be able to list three typical types of mine hoist parts that require lubrication.

The trainee will be able to list examples of each type of part that requires lubrication.

The trainee will be able to list the two types of lubricant.

The trainee will be able to describe the methods of application for each type of lubricant. Given an illustration of the different lubrication systems where each of the parts is labeled with a letter, the trainee will be able to:

1. label each system grease gun, oil flow, or oil reservoir;
2. write the name of each labeled part

The trainee will be able to write the information that must be known for proper mine hoist lubrication.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for lubrication.

## LUBRICATION

Lubrication prevents wear on surfaces that rub together and is a major part of machinery maintenance.

The typical parts of a mine hoist that require lubrication are:

- Bearings of all rotating parts
  - hoist motor
  - overspeed and overtravel control
  - hoist drum
  - air compressor
  - head and other sheaves
  - hydraulic pump
- Joints of operating mechanisms
  - brake
  - clutch
  - safety dogs
  - limit switches
  - hoist operating controls
- Other surfaces that rub together
  - shaft guides and conveyance guide shoes
  - hoist rope

The types of lubricant are:

- oil
- grease

The methods of application are:

- Oil
  - Oil Reservoir

The bearing or part to be lubricated is submerged in oil. A dipstick or sight glass is provided to indicate if the oil is at the proper level. (See Figure 1)

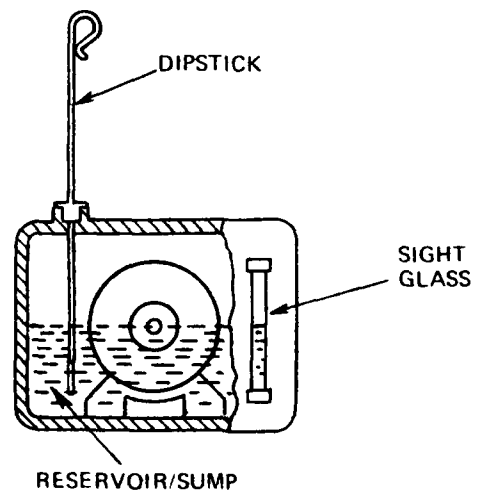


Figure 1

- Oil Flow System

Oil is fed to the bearing from an elevated tank by gravity or by a pump. After flowing through the bearing, the oil drains into a sump. A pump takes the oil out of the sump and pumps it to an elevated tank or directly to the bearing. A sight glass is usually provided to show whether or not oil is flowing in the required amount. A sight glass or dip stick can be used to show if there is sufficient oil in the tank or sump. The gauge measures oil pressure. (See Figure 2)

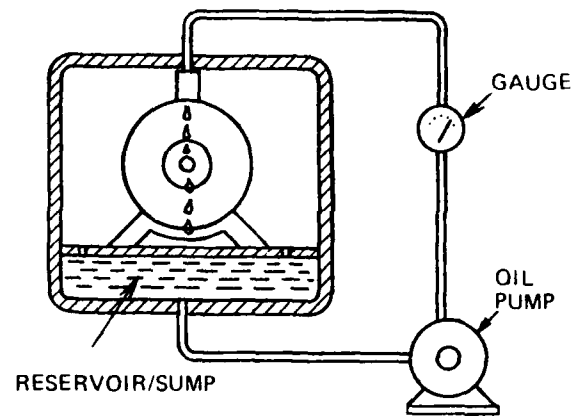


Figure 2

- Grease

Grease is forced between the parts to be lubricated (shaft and bearing, for example) by a grease gun. (see Figure 3)

The gun may be attached or portable. If it is attached it may be operated automatically or manually.

An adequate supply of grease should always be in the gun.

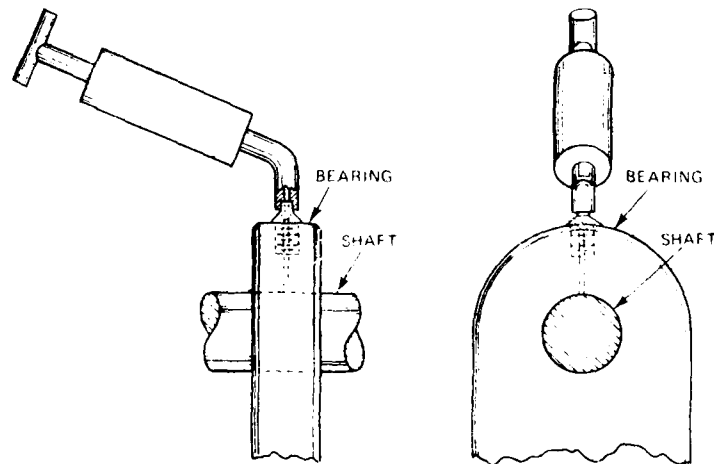


Figure 3

The person responsible for lubricating the hoist machinery must know:

- the parts to be lubricated
- the method of lubricating each part
- the type of lubricant (grade and weight of oil—type of grease) used for each part
- the location of the lubricant storage

The application of the lubricant to the shaft guides is usually done with a mop or brush.

The application of the lubricant to the hoist rope will be covered in that unit.

The manufacturers of practically all equipment include recommendations for lubrication in the instruction manual. These recommendations may be modified in your organization by the people responsible for maintenance. These instructions or modified instructions should be followed closely.

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic Mines**

57.19-121 *Mandatory*. Complete records shall be kept for three years of inspections, tests, and maintenance of shafts and hoisting equipment.

57.19-123 *Mandatory*. Wire ropes shall be lubricated or treated with dressing as recommended or approved by the rope manufacturer.

57.19-134 *Mandatory*. Sheaves in operating shafts shall be inspected weekly and kept properly lubricated.

57.19-135 *Mandatory*. Rollers used in operating inclined shafts shall be lubricated, properly aligned, and kept in good repair.

## PRACTICE QUESTIONS FOR LUBRICATION

Complete these sentences with the correct answers:

1. Lubrication prevents wear on surfaces that \_\_\_\_\_.
2. Typical parts of a mine hoist that require lubrication are \_\_\_\_\_ of all rotating parts, \_\_\_\_\_ of operating mechanisms, and other \_\_\_\_\_ that rub together.
3. Two examples of mine machinery that might have bearings to lubricate are \_\_\_\_\_ and \_\_\_\_\_.
4. Two examples of mine machinery that might have joints to lubricate are \_\_\_\_\_ and \_\_\_\_\_.
5. Two examples of other surfaces that rub together are: \_\_\_\_\_ and \_\_\_\_\_.
6. The types of lubricant are \_\_\_\_\_ and \_\_\_\_\_.
7. Oil can be applied by an \_\_\_\_\_ or an \_\_\_\_\_.
8. In a/an \_\_\_\_\_ the bearing or part to be lubricated is submerged in oil.
9. In a/an \_\_\_\_\_ oil is fed to the bearing from an elevated tank by gravity or by a pump.
10. A grease gun may be attached to the machine and operated \_\_\_\_\_ or \_\_\_\_\_, or the gun may be \_\_\_\_\_.
11. The person responsible for lubricating hoist machinery must know:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_
12. Instructions for lubrication come from:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_

**Federal Regulations for Metal and Nonmetallic Mines**

13. Complete \_\_\_\_\_ shall be kept for three years of inspections, tests, and maintenance of shafts and hoisting equipment.
14. \_\_\_\_\_ shall be lubricated or treated with dressing as recommended or approved by the rope manufacturer.
15. \_\_\_\_\_ used in operating inclined shafts shall be lubricated, properly aligned, and kept in good repair.
16. \_\_\_\_\_ in operating shafts shall be inspected weekly and kept properly lubricated.



## ANSWERS TO LUBRICATION PRACTICE QUESTIONS

1. rub together
2. bearings; joints; surfaces
3. hoist motor                      air compressor  
overspeed & overtravel      head and other sheaves  
control                          hydraulic pump  
hoist drum
4. brake                      limit switches  
clutch                      hoist operating controls  
safety dog
5. shaft guides and conveyance guide shoes; hoist rope
6. oil; grease
7. oil reservoir; oil flow system
8. oil reservoir
9. oil flow system
10. automatically; manually; portable
11. A. the parts to be lubricated  
B. the method of lubricating each part  
C. the type of lubricant to be used  
D. the location of the lubricant storage
12. manufacturers instruction manual  
people in the mine responsible for maintenance
13. records
14. Wire ropes
15. Rollers
16. Sheaves

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 17

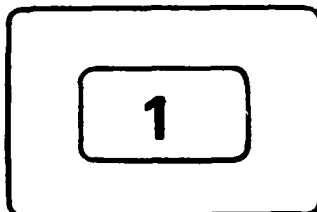
# INSPECTION



## OBJECTIVE

The trainee will know requirements and federal regulations for inspection requirements

## TIME



## **INSTRUCTIONAL OBJECTIVES FOR INSPECTION**

The trainee will be able to state in one or two sentences the function (use) of inspection.

The trainee will be able to write the requirements for proper hoist inspection.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for inspection.

## INSPECTION

Periodic inspections of the hoist, shaft and related parts are made to assure that operations can be conducted safely. This unit outlines basic inspection requirements. You will learn detailed requirements from your mine's rules and regulations.

The hoist operator must know:

1. hoist parts that require inspection;
2. how often these parts require inspection;
3. conditions which indicate maintenance or attention is required;
4. method of recording information in log.

A typical inspection schedule may be:

### At the beginning of each shift

The hoist operator examines the hoist and tests overtravel, overspeed, deadman controls, position indicators, and braking mechanisms. This includes:

- visually checking
  - wiring for loose connections, damaged insulation
  - hoist housing, structure and drum for loose bolts, cracks and similar defects
  - brake mechanism for loose/worn shoes, mechanical defects, hydraulic pressure
  - safety cable for lubrication, broken wires, deformation
  - conveyance for loose, missing or broken parts
  - safety dogs
- operating hoist full length of the shaft to make sure that
  - shaft is clear and will accommodate skip cage
  - appearance and sound of running hoist is normal
  - wire rope has no apparent defects
  - depth indicator, ammeter, rope speed meter, and other functioning properly
  - brakes, clutches and other parts are normal
- testing the following
  - communication systems
  - overspeed controls
  - overwind controls
  - slack rope cut-off

### Daily - Visually Examine

- Rope and conveyance connections to conveyances and drum should be checked.
- The hoist operator should look for abnormalities in the rope, including:
  - reduction in rope diameter
  - stretching of the rope
  - worn, broken or corroded wires
  - indications of mechanical abuse
  - abrasions
- Safety catches
- Sheaves
- Shaft (coal)

### Weekly

- Shaft (Metal and Nonmetallic)

The manufacturers of most equipment include recommendations for inspection in the instruction manual. These recommendations may be modified in your organization by the people responsible for maintenance. These instructions or modified instructions should be followed closely.

## **FEDERAL REGULATIONS (From Title 30 CFR)**

### **Metal and Nonmetallic Mines**

**57.19-20 *Mandatory.*** A systematic procedure of inspection, testing, and maintenance of shaft and hoisting equipment shall be developed and followed. If it is found or suspected that any part is not functioning properly, the hoist shall not be used until the malfunction has been located and repaired or adjustments have been made.

**57.19-121 *Mandatory.*** Complete records shall be kept for three years of inspections, tests, and maintenance of shafts and hoisting equipment.

**57.19-124 *Mandatory.*** Hoist ropes other than those on friction hoists shall be cut off at least six (6) feet above the highest connection to the conveyance at time intervals not to exceed one (1) year unless a shorter time is required by standard 57.19-126, or by conditions of use. The portion of the rope that is cut off shall be examined and inspected by a competent person for damage, corrosion, wear and fatigue.

**57.19-125 *Mandatory.*** Hoist ropes wound in multiple layers shall have a length cut off at the drum end at least three (3) times during the anticipated life of the rope and whenever necessary as required by standard 57.19-126 to distribute the wear at change-of-layer and crossover points. The length of rope cut off shall not be a whole number multiple of the circumference of the drum.

**57.19-126 *Mandatory.*** Hoist ropes shall be examined over the entire active length at least every month to evaluate wear and possible damage. When such examinations or other inspections reveal that the rope is worn, and at least every six (6) months, caliper measurements or nondestructive tests shall be made at the following locations:

- (a) Wherever wear is evident.
- (b) Immediately above the socket or clip and above the safety connection.
- (c) Where the rope rests on the sheaves.
- (d) Where the ropes leave the drums when the conveyances are at the regular stopping point.
- (e) Where a layer of rope begins to overlap another layer on the drum.
- (f) At 100 foot intervals (measurements shall be made midway between the last previously calipered points).

**57.19-127** Electromagnetic or other nondestructive rope testing systems shall be used only as supplements to and not as substitutes for recommended inspection and tests.

**57.19-128 *Mandatory.*** Ropes shall not be used for hoisting when they have:

- (a) More than six broken wires in any lay.
- (b) Crown wires worn to less than 65 percent of the original diameter.
- (c) A marked amount of corrosion or distortion.
- (d) A combination of similar factors individually less severe than those above but which in aggregate might create an unsafe condition.

57.19-129 *Mandatory*. Hoistmen shall examine their hoists and shall test overtravel, deadman controls, position indicators, and braking mechanisms at the beginning of each shift.

57.19-130 *Mandatory*. Before hoisting persons and to assure that the hoisting compartments are clear of obstructions, empty hoist conveyances shall be operated at least one round trip after:

- (a) Any hoist or shaft repairs or related equipment repairs that might restrict or obstruct conveyance clearance.
- (b) Any oversize or overweight material or equipment trips that might restrict or obstruct conveyance clearance.
- (c) Blasting in or near the shaft that might restrict or obstruct conveyance clearance.
- (d) Remaining idle for one shift or longer.

57.19-131 *Mandatory*. Hoist conveyance connections shall be inspected at least once during any 24-hour period that the conveyance is used for hoisting persons.

57.19-132 *Mandatory*.

- (a) A performance drop test of hoist conveyance safety catches shall be made at the time of installation, or prior to installation, in a mockup of the actual installation. The test shall be certified to in writing by the manufacturer or by a registered professional engineer performing the test.
- (b) After installation and before use, and at the beginning of any seven (7) day period during which the conveyance is to be used, the conveyance shall be suitably rested and the hoist rope slackened to test for the unrestricted functioning of the safety catches and their activating mechanisms.
- (c) The safety catches shall be inspected by a competent person at the beginning of any 24-hour period that the conveyance is to be used.

57.19-133 *Mandatory*. Shafts that have not been inspected within the past 7 days shall not be used until an inspection has been conducted by a competent person.

57.19-134 *Mandatory*. Sheaves in operating shafts shall be inspected weekly and kept properly lubricated.

57.19-135 *Mandatory*. Rollers used in operating inclined shafts shall be lubricated, properly aligned, and kept in good repair.

## **Coal Mines**

### **75.1400-2 HOISTS; TESTS OF SAFETY CATCHES; RECORDS**

A record shall be made in a book of the tests, required by 75.1400, of the safety catches or other devices approved by the Secretary. Each entry shall be signed by the person making the tests and countersigned by a responsible official.

### **75.1400-3 DAILY EXAMINATION OF HOISTING EQUIPMENT**

The daily examination required by 75.1400, of hoisting equipment, including automatic elevators shall include but not be limited to the following:

- (a) A visual examination of the rope for wear, broken wires, and corrosion, especially at excessive strain points, such as near the attachments, where the rope rests on the sheaves and where the rope leaves the drum at both ends.

- (b) An examination of the rope fastenings for defects.
- (c) An examination of safety catches.
- (d) An examination of the cage, platforms, elevators, or other devices for loose, missing, or defective parts.
- (e) An examination of the head sheaves to check for broken flanges, defective bearings, rope alignment, and proper lubrication.
- (f) An observation of the lining and all other equipment and appurtenances installed in the shaft.

**75.1400-4 DAILY EXAMINATIONS OF HOISTING EQUIPMENT; RECORDS.**

Records of the daily examinations of hoisting equipment required by 75.1400 shall be kept listing all items examined. Daily entries shall be signed by the person or persons making examinations. The reports of the examinations shall be read and countersigned by a responsible company official daily.

**75.1402-2 TESTS OF SIGNALING SYSTEMS**

Signaling systems used for communication between shaft stations and the hoist room shall be tested daily.

## PRACTICE QUESTIONS FOR INSPECTION

Complete these sentences with the correct answers:

1. Periodic inspections of the hoist, shaft and related parts are made to assure that operations can be conducted \_\_\_\_\_ .
2. In order to inspect the hoist properly, the hoist operator should know:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_

### FEDERAL REGULATIONS

#### Metal and Nonmetallic Mines

3. A systematic procedure of inspection for shaft and hoisting equipment shall be \_\_\_\_\_ .
4. The hoist equipment shall not be used if a malfunction is \_\_\_\_\_ .
5. Complete records shall be kept for three years of inspections, tests, and maintenance of \_\_\_\_\_ .
6. The hoist operator, at the beginning of each shift, shall examine the hoist and test:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_
7. Before hoisting persons and to assure that the hoisting compartments are clear of obstructions, empty hoist conveyances shall be operated at least one round trip after:
  - (a) Any hoist or shaft repairs or related equipment repairs that might restrict or obstruct \_\_\_\_\_ .
  - (b) Any oversize or overweight \_\_\_\_\_ that might restrict or obstruct conveyance clearance.
  - (c) Blasting in or near the shaft that might \_\_\_\_\_ conveyance clearance.
  - (d) Remaining idle for one \_\_\_\_\_ or longer.



8. Conveyance connections shall be inspected at least \_\_\_\_\_ during any 24-hour period the conveyance is used for hoisting people.
9. A performance drop test of hoist conveyance safety catches shall be made \_\_\_\_\_, or prior to installation, in a mockup of the actual installation.
10. After installation and before use, and at the beginning of any \_\_\_\_\_ period during which the conveyance is to be used, the conveyance shall be suitably rested and the hoist rope slackened to test for the unrestricted functioning of the safety catches and their \_\_\_\_\_.
11. The safety catches shall be inspected by a competent person at the beginning of any \_\_\_\_\_ period that the conveyance is to be used.
12. Shafts that have not been inspected within the past \_\_\_\_\_ shall not be used until an inspection has been conducted by \_\_\_\_\_.
13. Sheaves in operating shafts shall be inspected \_\_\_\_\_ and kept properly lubricated.
14. Hoist ropes shall be examined over the entire active length at least every month to evaluate \_\_\_\_\_.
15. When such examinations or other inspections reveal that the rope is worn, and at least every six (6) months, caliper measurements or nondestructive tests shall be made at the following locations:
  - (a) Wherever \_\_\_\_\_ is evident.
  - (b) Immediately above the socket or clip and above the \_\_\_\_\_.
  - (c) Where the rope \_\_\_\_\_ on the sheaves.
  - (d) Where the ropes leave the \_\_\_\_\_ when the conveyances are at the regular stopping point.
  - (e) Where a layer of rope begins to \_\_\_\_\_ another layer on the drum.
  - (f) At \_\_\_\_\_ intervals (measurements shall be made midway between the last previously calipered points).
16. Rollers used in operating inclined shafts shall be lubricated, properly \_\_\_\_\_, and kept in \_\_\_\_\_.
17. Electromagnetic or other nondestructive rope testing systems shall be used only as supplements to and not as substitutes for recommended \_\_\_\_\_ and \_\_\_\_\_.

18. Ropes shall not be used for hoisting when they have:
- (a) More than \_\_\_\_\_ broken wires in any lay.
  - (b) Crown wires worn to less than \_\_\_\_\_ percent of the original diameter.
  - (c) A marked amount of \_\_\_\_\_ or \_\_\_\_\_.
  - (d) A combination of similar factors individually less severe than those above but which in aggregate might create \_\_\_\_\_.
19. Hoist ropes other than those on friction hoists shall be cut off at least \_\_\_\_\_ above the highest connection to the conveyance at time intervals not to exceed one (1) year unless a shorter time is required by standard 57.19-126, or by \_\_\_\_\_.
20. The portion of the rope that is cut off (question 19) shall be examined and inspected by a competent person for \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
21. Hoist ropes wound in multiple layers shall have a length cut off at the drum end at least \_\_\_\_\_ times during the anticipated life of the rope and \_\_\_\_\_, as required by standard 57.19-126 to distribute the wear at change-of-layers and crossover points.
22. The length of rope cut off (question 21) shall not be a \_\_\_\_\_ of the circumference of the drum.

#### Coal Mines

23. Records shall be kept of tests performed on safety catches and other devices. Each entry will be signed by \_\_\_\_\_ and countersigned by \_\_\_\_\_.
24. Daily examination of hoisting equipment shall include, but not be limited to:
- A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_
  - E. \_\_\_\_\_
  - F. \_\_\_\_\_
25. Records of the daily required examinations shall be kept listing all items examined. Daily entries shall be signed by \_\_\_\_\_. The reports shall be read and countersigned by \_\_\_\_\_ daily.
26. Signaling systems used for communication between shaft stations and the hoist room shall be tested (circle one):            daily            weekly            monthly

## ANSWERS TO INSPECTION PRACTICE QUESTIONS

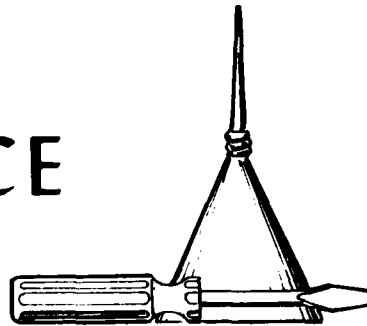
1. safely.
2.
  - A. parts that require inspection
  - B. how often these parts require inspection
  - C. conditions that indicate maintenance or attention is required
  - D. method of logging
3. developed and followed.
4. found or suspected.
5. shafts and hoisting equipment.
6.
  - A. overtravel
  - B. deadman controls
  - C. position indicators
  - D. braking mechanisms
7.
  - (a) conveyance clearance.
  - (b) material or equipment trips
  - (c) restrict or obstruct
  - (d) shift
8. once
9. at the time of installation
10. seven (7) day; activating mechanisms.
11. 24-hour
12. 7 days; a competent person.
13. weekly
14. wear and possible damage.
15.
  - (a) wear
  - (b) safety connection
  - (c) rests
  - (d) drums
  - (e) overlap
  - (f) 100 foot
16. aligned; good repair.
17. inspections; tests.

- 18. (a) six
  - (b) 65
  - (c) corrosion; distortion
  - (d) an unsafe condition.
- 19. six (6) feet; conditions of use.
- 20. damage, corrosion, wear, fatigue.
- 21. three (3); whenever necessary
- 22. whole number multiple
- 23. the person making the test; a responsible official.
- 24. A. visual examination of rope for wear, broken wires and corrosion, especially at excessive strain points.
  - B. examining rope fastenings for defects
  - C. examining safety catches
  - D. examining cages, platforms, elevators or other devices for loose, missing or defective parts.
  - E. examining head sheaves for broken flanges, defective bearings, rope alignment, and proper lubrication.
  - F. examining lining, equipment, and other parts of the shaft.
- 25. person or persons making the examination; a responsible company official
- 26. daily

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 18

# MAINTENANCE



## OBJECTIVE

The trainee will know the requirements and federal regulations for maintenance

## TIME

1/2

## INSTRUCTIONAL OBJECTIVES FOR MAINTENANCE

The trainee will be able to state in one or two sentences the function (use) of maintenance.

The trainee will be able to answer multiple-choice questions concerning:

1. work included in maintenance
2. two kinds of maintenance
3. sources of maintenance instructions.

The trainee will be able to answer in writing multiple-choice questions concerning the application of federal regulations for maintenance.

## MAINTENANCE

Maintenance is the work that is done to keep the mine hoist and its parts repaired and in safe operating condition.

Maintenance includes:

- housekeeping
- inspection
- lubrication
- repairs
- replacement of parts
- adjustments

There are two kinds of maintenance:

- corrective maintenance, which is repairing or replacing parts that have broken down.
- preventive maintenance, which is repairing, adjusting, or replacing parts before they break down.

This work may be the responsibility of the hoist operator or the maintenance personnel. In either case the hoist operator must have a systematic procedure and adequate records to assure that the required work is done according to regulations.

Maintenance instructions come from several sources:

- federal, state or local regulations
- maintenance manuals put out by the manufacturers of the hoist, hydraulic systems, and other systems
- maintenance procedures put out by the mine foreman, maintenance foreman and other mine managers.

The hoist operator should know the maintenance procedures required to be performed

- pre-shift
- post-shift
- daily
- weekly
- monthly
- annually

and the person responsible for doing each.

He/she should have a record of when each task was performed and who performed it.

A check-off list with the above information is a must for a good maintenance program.

## FEDERAL REGULATIONS (From Title 30 CFR)

### Metal and Nonmetallic Mines

57.19-107 *Mandatory.* Hoistmen shall be informed when men are working in a compartment affected by that hoisting operation and "Men Working in Shaft" sign shall be posted at the hoist.

57.19-108 *Mandatory.* When men are working in a shaft "Men Working in Shaft" signs shall be posted at all devices controlling hoisting operations that may endanger such men.

57.19-109 *Mandatory.* Shaft inspection and repair work in vertical shafts shall be performed with substantial platforms equipped with bonnets or equivalent overhead protection.

57.19-122 *Mandatory.* Parts used to repair hoists shall have properties that will insure the proper and safe function of the hoist.



## PRACTICE QUESTIONS FOR MAINTENANCE

Complete these sentences with the correct answers:

1. Maintenance is the work that is done to keep the mine hoist and its parts \_\_\_\_\_.
2. Maintenance includes: \_\_\_\_\_.
3. There are two kinds of maintenance: \_\_\_\_\_, which is repairing or replacing parts that have broken down, and \_\_\_\_\_, which is repairing, adjusting, or replacing parts before they break down.
4. This work may be the responsibility of the \_\_\_\_\_ or the \_\_\_\_\_.
5. Maintenance instructions come from \_\_\_\_\_.
6. The hoist operator should know the maintenance procedures to be performed pre-shift, post-shift, daily, \_\_\_\_\_ and the person responsible for doing each.
7. Federal regulations for metal and nonmetallic mines require that a hoist operator be informed when men are working in a compartment affected by that hoisting operation. A \_\_\_\_\_ sign shall be posted at the hoist.
8. When men are working in a shaft, "Men Working in Shaft" signs shall be posted at all devices controlling hoisting operations that \_\_\_\_\_.
9. Repair work in vertical shafts shall be performed from substantial platforms equipped with \_\_\_\_\_.
10. Parts used to repair hoists shall have properties that will insure the \_\_\_\_\_.

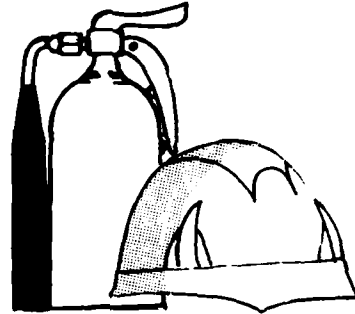
## ANSWERS FOR MAINTENANCE PRACTICE QUESTIONS

1. repaired and in safe operating conditions.
2. housekeeping, inspections, lubrication, repairs, replacement of parts.
3. corrective; preventive
4. hoist operator; maintenance personnel
5. federal, state and local regulations, manufacturers' maintenance manuals, procedures put out by mine and maintenance foremen and other mine managers.
6. weekly, monthly, annually
7. "Men Working in Shaft"
8. may endanger such men.
9. bonnets or equivalent overhead protection.
10. proper and safe function of the hoist.

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 19

### SAFETY FEATURES



### OBJECTIVE

The trainee will review the safety features  
of the hoist

### TIME

1/2

## INSTRUCTIONAL OBJECTIVES FOR SAFETY FEATURES

The trainee will be able to describe the different safety features.

Given a list of safety features where each feature is labeled with a letter, and a list of the uses of these safety features, the trainee will be able to match each feature to its use.

The trainee will be able to answer in writing multiple-choice questions concerning the hoist operator's safety responsibilities.

The trainee will be able to answer in writing multiple-choice questions concerning the sources of safety practices.

## **SAFETY FEATURES**

The hoist operator is responsible for the safe operation of the mine hoist and for the condition of the hoist safety features. This unit presents a summary of the safety features of the hoist and their uses.

Built-in safety features found in most mine hoists are:

- slack rope switch—cuts off power to the hoist and applies the brakes on the drum if the rope breaks or goes slack.
- safety dogs—grip the shaft guides and prevent the conveyance from falling down the shaft if the rope breaks or goes slack.
- overspeed control—cuts off power to the hoist and applies the brake to the drum if the conveyance travels too fast.
- overtravel control—cuts off the power to the hoist if the conveyance travels too far above the collar or too far below the lowest landing.
- clutch brake interlock—requires the brakes to be applied to a drum before the clutch can be disengaged.
- cage bonnet—protects persons in the cage from being struck by falling objects (tools, rocks, dirt) in the shaft.
- safety gates—prevent persons and objects from falling into an open shaft.
- communication systems—provide communication links between the hoist operator and persons in or near the shaft.
- deadman switch—cuts power to the hoist and applies the brake if the hoist operator is disabled.
- rope strength—reduces the probability of the rope breaking because of additional strain due to acceleration, deceleration, jerky hoist operation, overloads.

These features contribute to safe operation. The hoist operator must make sure that each of these features is working properly.

Safe operation of the mine hoist also depends upon the alertness of the hoist operator and the way he/she does his/her job. He/she must know the hoist operation thoroughly, be skilled at his/her job, be alert to possible unsafe conditions, and have a positive attitude toward safety.

Proper inspection, maintenance, housekeeping, and operation procedures by the hoist operator contribute to safety.

## **RULES AND REGULATIONS**

Established operating procedures, federal, state and local regulations are the primary sources of safety practice .

Federal regulations affecting the operation of the mine hoist are issued and revised periodically. Current mandatory federal regulations for each hoist part and hoisting procedure are given in the descriptions.

## PRACTICE QUESTIONS FOR SAFETY FEATURES

Complete each sentence with the correct answer:

1. The \_\_\_\_\_ prevents the clutch from being disengaged unless the brakes are applied to the drum.
2. Persons in a cage are protected from falling objects by the \_\_\_\_\_.
3. If the rope breaks or goes slack, power to the hoist is cut off and the brakes are applied to the drum by the \_\_\_\_\_.
4. The probability of the rope breaking because of additional strain due to acceleration, jerky hoist operation or overloads is reduced because of \_\_\_\_\_.
5. If the rope breaks or goes slack, the conveyance is prevented from falling down the shaft by the \_\_\_\_\_, which grip the shaft guides.
6. Persons and objects are prevented from falling into an open shaft by \_\_\_\_\_.
7. If the conveyance travels too fast, power to the hoist is cut off and the brakes are applied to the drum by the \_\_\_\_\_.
8. The \_\_\_\_\_ cuts power to the hoist and applies the brake if the hoist operator is disabled.
9. Communication links between the hoist operator and persons in or near the shaft are provided by the \_\_\_\_\_.
10. If the conveyance travels too far above the collar or too far below the lowest landing, the \_\_\_\_\_ cuts off the power to the hoist.
11. Safe operation of the mine hoist depends upon the \_\_\_\_\_ of the hoist operator, his/her knowledge of the \_\_\_\_\_, his/her skill at the job, and his/her \_\_\_\_\_ attitude toward the job.
12. The hoist operator contributes to safety by proper \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ procedures.
13. The primary sources of safety practices are \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ regulations and established \_\_\_\_\_.

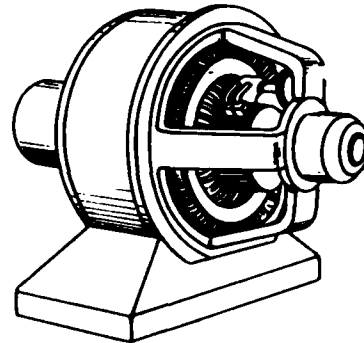
## ANSWERS TO SAFETY FEATURES PRACTICE QUESTIONS

1. clutch-brake interlock
2. cage bonnet.
3. slack rope switch.
4. rope strength.
5. safety dogs
6. safety gates.
7. overspeed control.
8. deadman switch
9. communication systems.
10. overtravel control
11. alertness; hoist operation; positive
12. inspection, maintenance, housekeeping; operation
13. federal, state; local; operating procedures.

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 20**

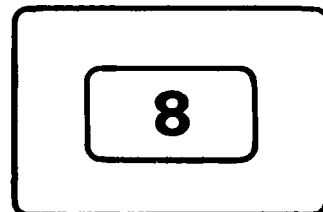
### **ELECTRICAL SYSTEM (FUNDAMENTALS)**



#### **OBJECTIVE**

The trainee will know the operating principles,  
major components and safety guidelines  
for the electrical system

#### **TIME**





## INSTRUCTIONAL OBJECTIVES FOR THE ELECTRICAL SYSTEM

The trainee will be able to write in one or two sentences the function of the electrical system.

The trainee will be able to answer in writing questions concerning the basic principles of:

1. electricity
2. magnetism
3. direct current motors
4. alternating current motors
5. direct current generators
6. alternating current generators
7. transformers
8. fuses and circuit breakers
9. work and power relationships
10. safety precautions for electricity

The trainee will be able to solve simple problems using Ohm's Law.

## BASIC ELECTRICAL PRINCIPLES

Electricity provides energy for operating the mine hoist and other equipment and for lighting and heating. (See Figure 1)

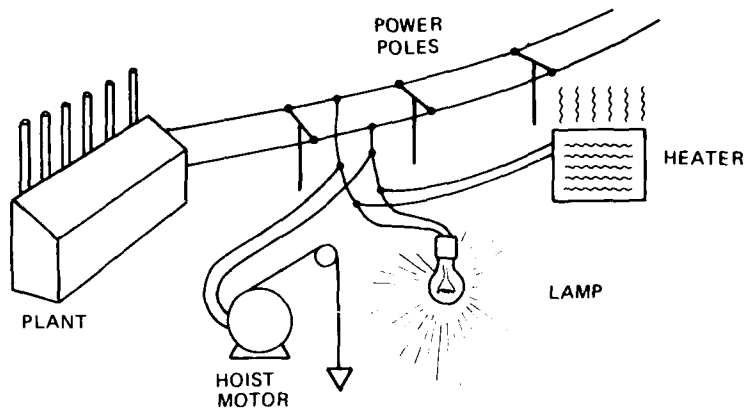


Figure 1

Like other forms of energy, electricity, if not carefully controlled, can cause injuries to people and damage to equipment.

A knowledge of the material in this unit will enable the hoist operator to operate the mine hoist and its supporting equipment with a high degree of safety from electrical hazards.

### ELECTRICITY

Electrical energy is created by a flow of negatively charged atomic particles called electrons. If there are more electrons at point A (Figure 2) than there are at point B, and there is a path (conductor) through which the electrons can flow, electrons will move from point A to B

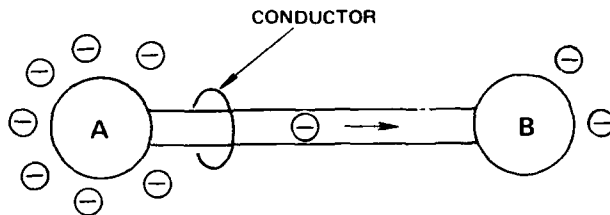


Figure 2

until an equal number are at each point (Figure 3).

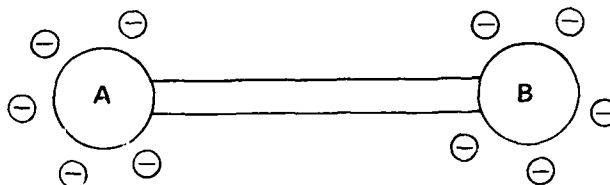


Figure 3

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MINE HOIST OPERATOR TRAINING PROGRAM. INSTRUCTION MANUAL. (U)  
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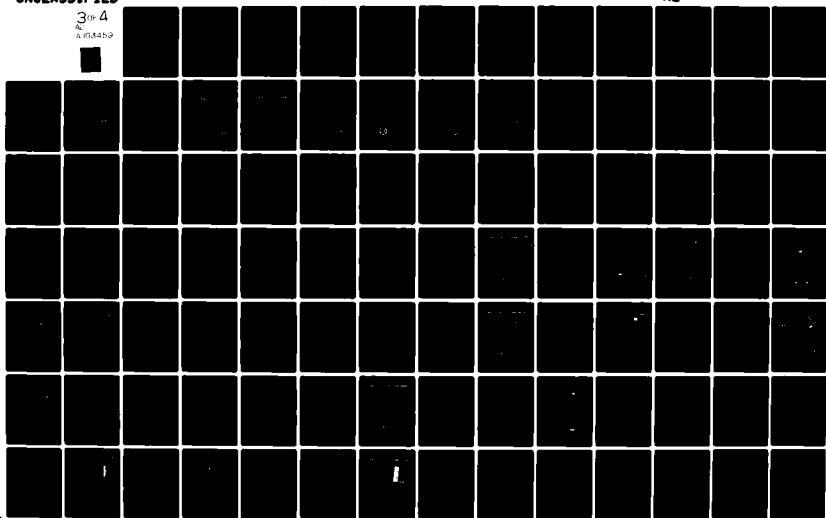
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The excess number of electrons at A in Figure 2 created a pressure, causing the electrons to flow to point B. You can compare the action to the two tanks of water in Figure 4.

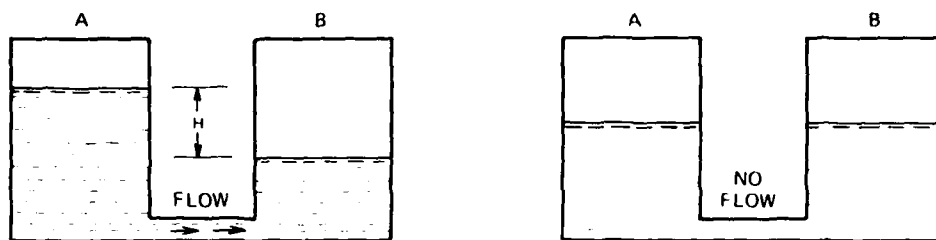


Figure 4

The greater water pressure caused by the greater height of the water in A (H) will cause water to flow into B until the water in each tank is at the same height.

## PRESSURE AND CURRENT

### Volts and Amperes

In electricity the "pressure" causing the flow is called voltage. The rate of flow of electrons is called current.

A unit of voltage is one Volt.

Its symbol is E.

A unit of current is one Ampere.

Its symbol is I.

It is important to remember that if there is a difference in voltage and a path along which electricity will flow (a conductor) between two points, current will flow from the high voltage to the low voltage point.

## RESISTANCE - OHMS

In the water system resistance is a restriction that opposes the flow of water. For example, if we use a smaller pipe between the two tanks, the rate of flow of the water will be less than if we use a larger pipe. With the smaller pipe we have put a resistance to the flow of water in the path (See Figure 5).

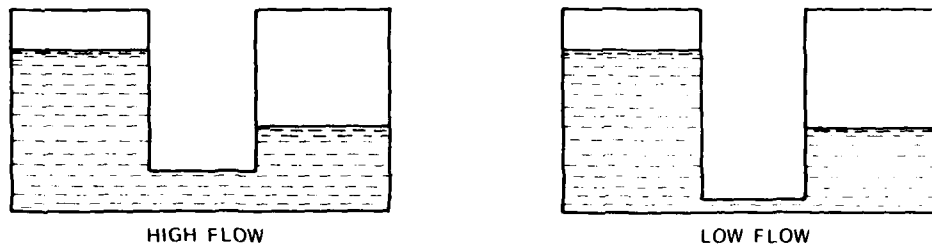


Figure 5

If we put a resistance in the path of the electrons (a smaller conductor or a conductor of a material that does not allow electrons to flow as well), Figure 6, the rate of flow of electrons will be reduced.

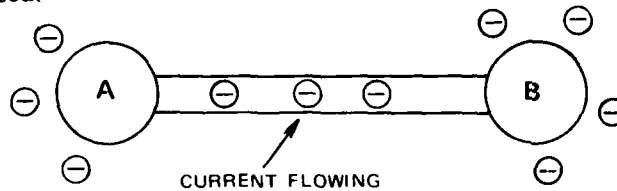


Figure 6

In an electrical circuit a unit of resistance to flow is an Ohm.

Its symbol is R.

Now go to the Questions and answer 1 through 10

There is a relationship between the number of volts, amperes, and ohms in an electrical circuit. It is called Ohm's Law.

Here are the relationships:

$$\text{Volts} = \text{Amperes} \times \text{Ohms}$$

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

Symbols

$$E = IR$$

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

These relationships enable us to find one unknown value if two others are known. For example, if we have 5 amperes flowing through a circuit with 10 ohms resistance, what is the voltage?

$$E (\text{Volts}) = I (\text{Amperes}) \times R (\text{Ohms})$$

$$\text{or, } E = 5 \times 10 = 50 \text{ Volts.}$$

The circuit would look like Figure 7.

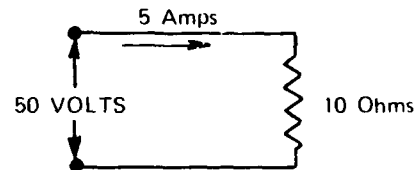


Figure 7

Or, if we have 100 volts across a 5 ohm resistance (Figure 8), how many amperes are there?

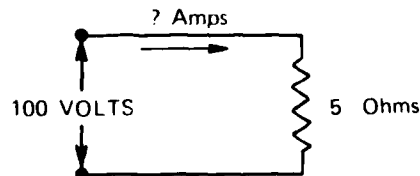


Figure 8

The current flow will be

$$I = \frac{E}{R} = \frac{100}{5} = 20 \text{ Amperes}$$

And, if we have 75 volts causing 25 amperes to flow in a circuit (Figure 9), what is the resistance in the circuit?

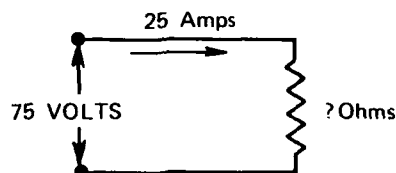


Figure 9

$$R = \frac{E}{I} = \frac{75}{25} = 3 \text{ Ohms.}$$

Now go to the Questions and answer 11 through 17

## SERIES AND PARALLEL CIRCUITS

There are two types of circuits: series and parallel (See Figure 10).

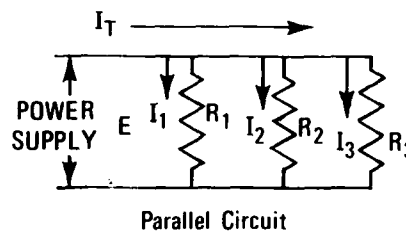
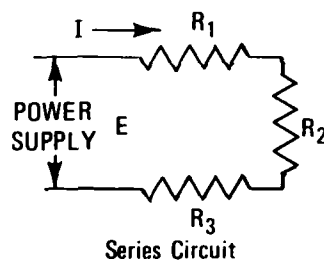


Figure 10

In a series circuit the same amount of current flows through each resistance (or load) in the circuit. The total resistance in the circuit is equal to the sum of the resistances, that is  $R_T = R_1 + R_2 + R_3$ . The current flowing through each resistance is equal to the voltage (E) divided by that sum:

$$I = \frac{E}{R_1 + R_2 + R_3}$$

In a parallel circuit the amount of current flowing through each resistance (or load) is equal to the voltage (E) divided by that resistance:

$$I_1 = \frac{E}{R_1}; I_2 = \frac{E}{R_2}; I_3 = \frac{E}{R_3}$$

The total current  $I_T = I_1 + I_2 + I_3$ .

For example, in a 100 volt series circuit there are 3 resistances, one of 5 ohms, one of 8 ohms, and one of 12 ohms. What is the current flow?

$$I = \frac{E}{R + R + R} = \frac{100}{5 + 8 + 12} = \frac{100}{25} = 4 \text{ Amperes.}$$

In a 100 volt parallel circuit we have three resistances (or loads), one of 5 ohms, one of 10 ohms, and one of 20 ohms. How much current flows through each one? What is the total current?

$$I_1 = \frac{E}{R_1} = \frac{100}{5} = 20 \text{ amps}$$

$$I_2 = \frac{E}{R_2} = \frac{100}{10} = 10 \text{ amps}$$

$$I_3 = \frac{E}{R_3} = \frac{100}{20} = 5 \text{ amps}$$

$$I_T = I_1 + I_2 + I_3 = 20 + 10 + 5 = 35 \text{ amps}$$

Now go to the Questions and answer 18 and 19

---

## CONDUCTORS AND INSULATORS

Practically every substance will conduct electricity to some extent. Those that have low resistance are called Conductors; those that have high resistance are called Non-conductors. Non-conductors are used as Insulators.

Commonly used conductors are listed below from lowest to highest resistance:

- Silver
- Copper
- Gold
- Aluminum
- Carbon

Silver, of course, is used only in rare cases, and in very limited amounts because of its cost.

The best and most commonly used non-conductors are:

- Rubber
- Porcelain
- Glass
- Some Plastics

There is no perfect conductor or non-conductor.

Most conductors are in the form of wire, made of copper or aluminum.

The diameter of the wire is given in thousandths of an inch or Mils. A wire with a diameter of 5 thousandths of an inch is a 5 Mil wire. The cross-section of the wire in Figure 11 is 5 Circular Mils.

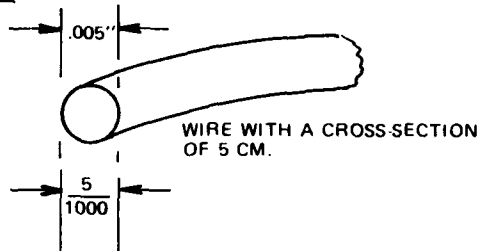


Figure 11

## ELECTRICAL POWER SYSTEMS

We can't actually see electricity flow through a wire and do work for us. We can, however, readily understand its basic operating principles by comparing it to a simple power system that is easily understood.

An electrical power system is similar to a water power system. Figure 12 is a sketch of a water powered system. Water is stored behind the dam and creates a pressure to force water through the pipe. When the valve is opened water flows through the pipe and turns the water wheel. The greater the pressure the greater the rate of flow of water. The greater the flow of water the greater the amount of power generated by the turning wheel.

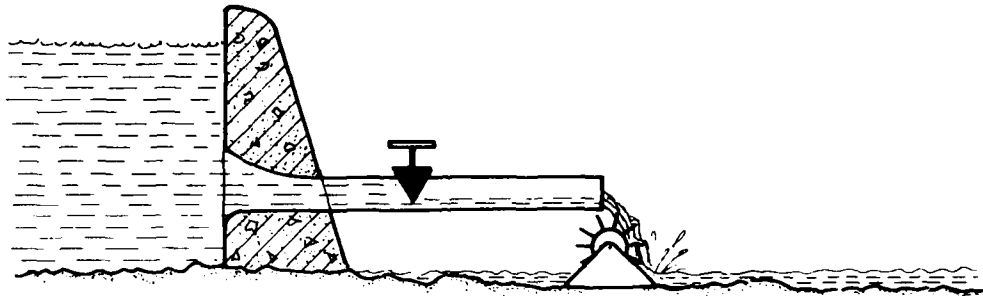


Figure 12

In an electrical power system, Figure 13, we have a similar situation. Electricity is like the water. It comes from a battery or generator and flows through wires or conductors. Remember that the pressure that forces it through the conductors is the voltage and the rate of flow of electricity is the current. Voltage is measured with a voltmeter; current is



measured with an ammeter. (See Figure 14) The greater the number of volts, the greater the number of amperes and the greater the amount of power, light, or heat that is generated.

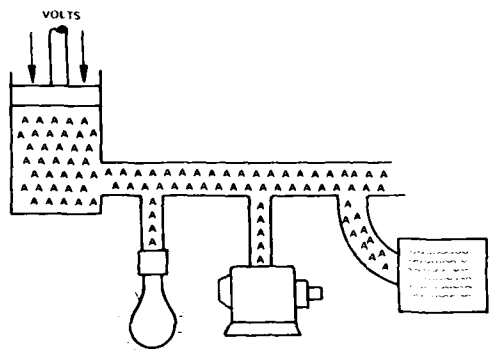


Figure 13

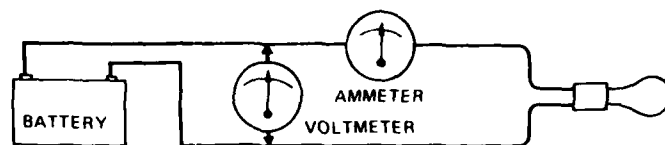


Figure 14

Too much pressure in a water system will increase the flow of water to the point that the pipes or equipment will be damaged (See Figure 15).

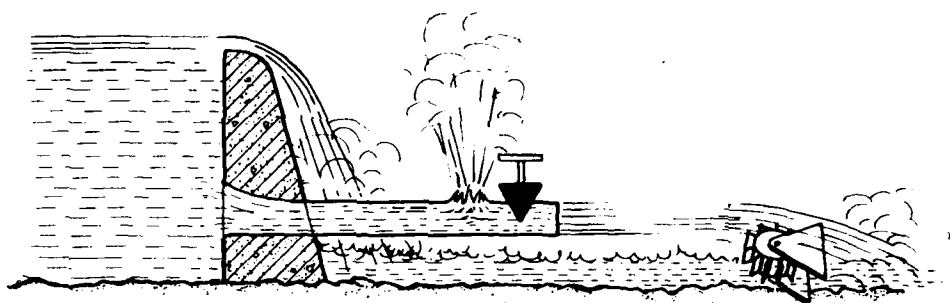


Figure 15

Too much voltage in an electrical system will increase the current to the point that the conductors or equipment will be damaged (See Figure 16).

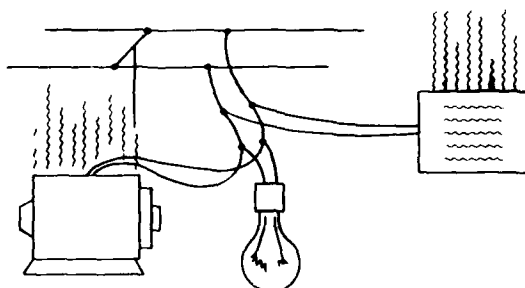


Figure 16

Now go to the Questions and answer 20 through 29

## POWER - WATTS

For our purpose, Power is the rate at which a motor or engine does work. Power is equal to the pounds lifted times the number of feet the pounds were lifted, divided by the number of seconds that it took to do the lifting.

$$\text{Power} = \frac{\text{Pounds} \times \text{Feet}}{\text{Seconds}}$$

A basic unit of power is foot pound per second. If a hoist lifts one pound one foot in one second it exerted one foot pound per second of power (Figure 17).

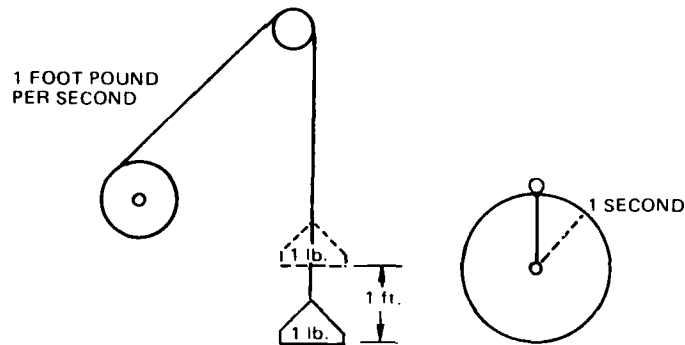


Figure 17

If the hoist lifts 5 pounds 10 feet in 2 seconds, it used 25 foot pounds per second of power (Figure 18).

$$(\text{Power} = \frac{5 \text{ pounds} \times 10 \text{ feet}}{2 \text{ seconds}} = 25 \text{ foot pounds per second})$$

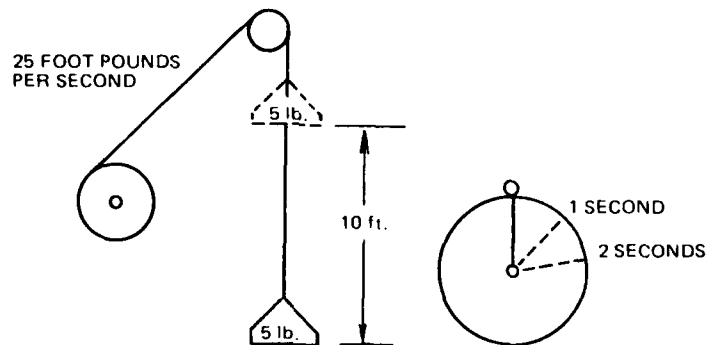


Figure 18

## WORK

The work done by the motor or engine is equal to the pounds that were lifted or force that was exerted, times the distance the pounds were lifted, or distance through which the force was exerted.

$$(\text{Work} = \text{Pounds} \times \text{Feet})$$

If we lift 1 pound 1 foot we do 1 foot pound of work. If we lift 1 pound 3 feet we do 3 foot pounds of work. If we lift 2 pounds 3 feet we do 6 foot pounds of work (Figure 19).

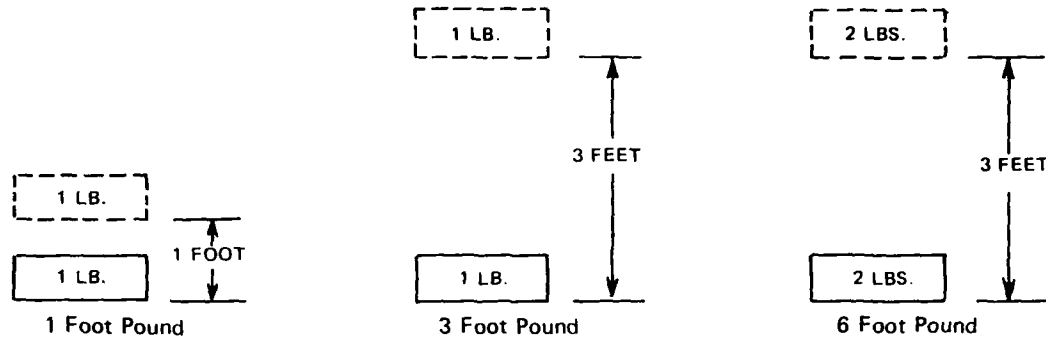


Figure 19

## WORK AND POWER

We can also determine the amount of work done by multiplying the power exerted by a motor or engine by the time that it operated ( $\text{Work} = \text{Power} \times \text{Seconds}$ ). For example, the hoist in Figure 18 raised 5 pounds 10 feet in 2 seconds. It did 50 foot pounds of work in 2 seconds, or 25 foot pounds each second.

$$25 \text{ foot pounds per second of power} \times 2 \text{ seconds} = 50 \text{ foot pounds of work}$$

## HORSEPOWER

Horsepower is a common term used to express power. One horsepower is the power needed to do 550 foot pounds of work in one second or 33,000 foot pounds of work in one minute. If a hoist has a 100 horsepower motor, it could do  $(550 \times 100)$  foot pounds of work in one second, that is, 55,000 foot pounds. It might lift a 550 pound weight 100 feet in one second or a 55,000 pound weight one foot in one second (Figure 20).

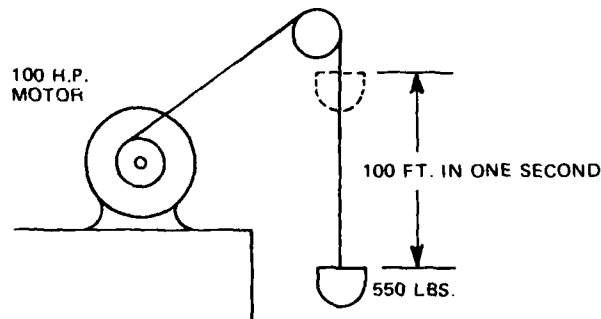


Figure 20

In one minute the 100 HP motor could hoist a 33,000 pound weight 100 feet.

Suppose your production hoist has two skips and tail ropes. The hoist will lift 15,000 pounds of ore at a speed of 2,200 feet per minute. If you ignore friction losses, how many horsepower are needed to run the hoist?

The work to be done in one minute is: 15,000 pounds x 2,200 feet = 33,000,000 foot pounds.

To convert the 33,000,000 foot pounds per minute to horsepower, divide the 33,000,000 foot pounds per minute by 33,000 foot pounds per minute for each horsepower.

$$\text{Power required is} = \frac{33,000,000}{33,000} = 1,000 \text{ horsepower}$$

We can find out how much work the motor has done by multiplying the power by the time that the power is used. For example, if the above hoist operates for 10 minutes, it will do 1,000 x 33,000 x 10 or 330,000,000 foot pounds of work.

Now go to the Questions and answer 30 through 40

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## WATTS, KILOWATTS AND KILOWATT HOURS

Power for electrical machinery is expressed in Watts. One horsepower is equal to 746 watts.

When one volt causes a one ampere current to flow in an electrical circuit, one watt of power is used. The symbol for Power is P. The power may hoist ore, turn a fan, pump water, light a lamp, or provide heat. Since the watt is a very small unit, we usually use the term Kilowatt, that is, 1,000 watts. If a one watt machine operates for one hour it will do one watt hour of work, or you can say that it used or expended one watt hour of energy. If a 10 Kilowatt machine operates for one hour, it does 10 Kilowatt hours of work.

Electric power used can be calculated by multiplying the voltage times the current flow, that is,  $P = E \times I$ . If 100 volts causes 5 amperes to flow in a circuit, the power used is  $P = E \times I = 100 \times 5 = 500$  watts. If the voltage and current flow continues for 2 hours, 1,000 watt hours of work (or one Kilowatt hour) are done. The power company bills the consumer on the number of Kilowatt hours of energy used.

## WATT HOUR METER

A Watt Hour Meter is used to measure the power or energy used. The watt hour meter actually measures the voltage and the amperage and combines the two measurements along with a time factor through a mechanical linkage in the meter.

Thus work or energy used = Volts x Amperage x Hours

## RESISTANCE AND POWER

We can use the Ohm's Law relationships on page I-A-20-4 to develop a similar formula for determining power. For example, we had:

$$P = E \times I$$

If we replace E with its formula ( $E = IR$ ) from page I-A-20-4 we have  $P = I \times R \times I$ , or  $I^2 \times R$ . Thus if we have 5 amperes flowing through a circuit with 40 ohms resistance, the power used in the circuit is:

$$P = I^2 \times R = 5 \times 5 \times 40 = 1000 \text{ Watts}$$

Now go to the Questions and answer 41 through 51

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The power that is used when current flows through the resistance in conductors turns into heat and is usually wasted. This fact creates two problems: one problem is the loss of power in transmission from the power company to the customer; the other problem is the creation of a fire hazard.

### TRANSMISSION OR LINE LOSSES

Suppose the mine receives power from the power company. The power company sends 100,000 watts at 1,000 volts and 100 amperes. Assume that the power lines have a resistance of 2 ohms.

In this case there will be a power transmission loss (line loss) of  $I^2 \times R = 100 \times 100 \times 2$ , or 20,000 watts. Thus while the power company sent 100,000 watts, we only receive 80,000.

If the power company sent the power at 2,000 volts and 50 amperes, the transmission or line loss would only be:  $I^2 \times R = 50 \times 50 \times 2$ , or 5,000 watts, and 95,000 watts would be received instead of 80,000.

Since line losses increase very rapidly as we increase the current, electricity is usually transmitted at very high voltage and low amperage.

The problem of a fire hazard is created when there is a poor connection, too small a conductor, or a damaged conductor between the power supply and the load that creates additional resistance. For example, a motor draws 10 amperes at normal load. If there is a bad connection in the conductor to the motor controls or switch boxes, the resistance at that point increases. For each ohm that it increases, 100 watts of power are lost and turn into heat.

$$P = I^2 \times R = 10 \times 10 \times 1 = 100$$

The heat may burn the insulation off the conductor, ignite flammable materials in the vicinity and start a fire.

Now go to the Questions and answer 52 through 58

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## ELECTRICITY AND MAGNETISM

The hoist motor and motor generator operate as they do because of certain relationships between electricity and magnetism. This section will explain those relationships.

If direct current electricity flows through a coil of wire that is wrapped around a piece of iron ("core") in the direction shown by the arrow  $\rightarrow$ , the iron will become a magnet. The magnetic lines of force are indicated. The magnet's North and South Poles will be as indicated by S and N. (See Figure 21). This kind of magnet is called an electromagnet since it is created by electricity.

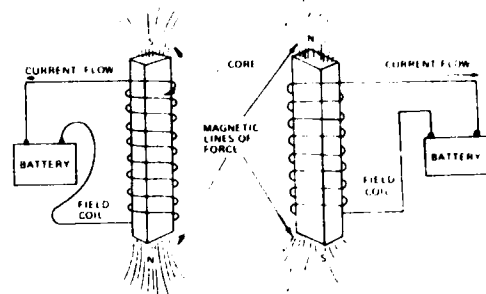


Figure 21

If the number of wire turns or the current flow through the turns is increased, the strength of the magnetic field will be increased (See Figure 22).

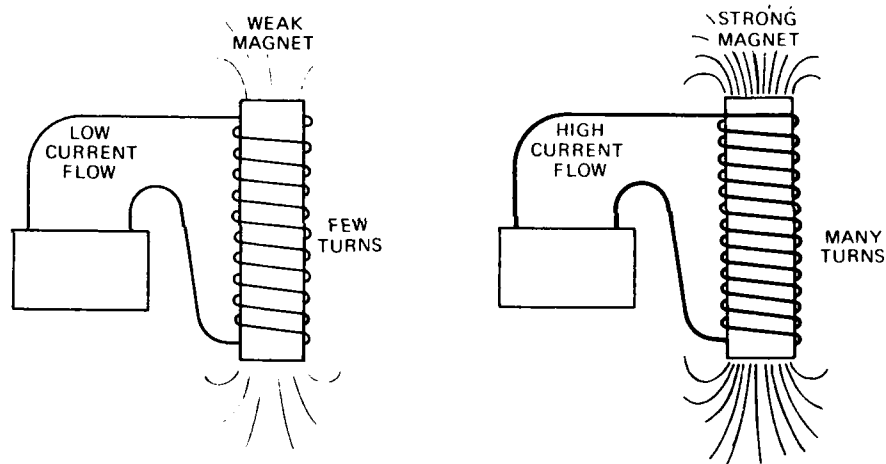


Figure 22

Opposite poles, an N and S, attract each other. (See Figure 23). Like poles, N and N or S and S repel each other (See Figure 24).

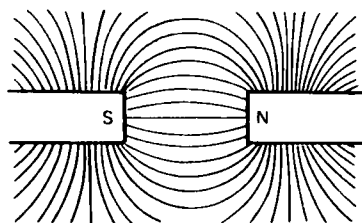


Figure 23

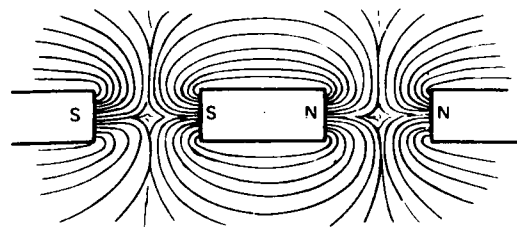


Figure 24

There are electromagnets inside the mine hoist motors. The attracting and repelling forces between the magnets cause the shaft of the hoist motor to turn.

In Figure 25A a wire is passed from left to right through the magnetic field. A voltage is generated in the wire. If the two ends of the wire are connected, current will flow.

In Figure 25B the direction of motion of the wire through the magnetic field is from right to left. The current flow is in the opposite direction from Figure 25A.

In Figure 25C the position of the poles of the magnetic field are opposite to those in Figure 25A. Changing the position of the poles changes the direction of current flow.

If the strength of the field is increased and/or the speed of the wire passing through the field is increased the voltage generated is increased.

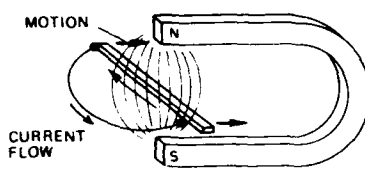


Figure 25A

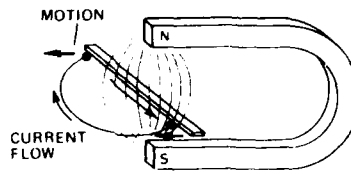


Figure 25B

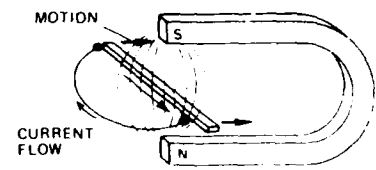


Figure 25C

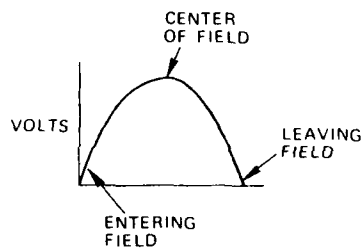


Figure 26

The voltage in the wire changes as the wire passes through a magnetic field. It is:

- Low on entering the field
  - At a peak in the center of the field
  - Low on leaving the field
- (See Figure 26).

The generator that supplies power to the hoist motor operates on these principles. Control of the hoist motor is also affected by these principles.

There are two kinds of electricity: Direct Current and Alternating Current. With direct current the voltage causes the current to flow in one direction only. The voltage may vary in the amount but not in the direction. (See Figure 27)

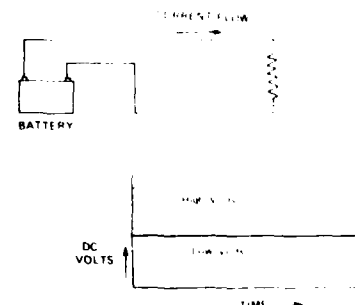


Figure 27

For alternating current the voltage causes current to flow first in one direction, then in the opposite direction. The voltage starts at zero, rises to a peak in one direction, drops to zero then to a peak in the opposite direction, then rises back to zero. (See Figure 28).

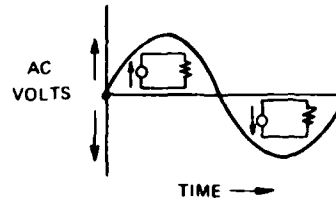


Figure 28

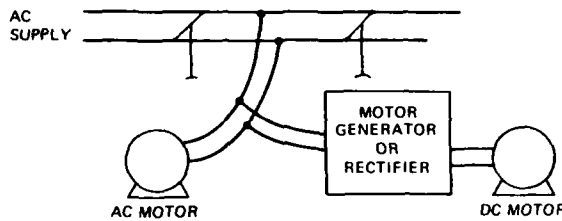


Figure 29

Most commercial electricity is generated and transmitted to the customer as alternating current. Some mine hoists and other mine equipment operate on alternating current while others operate on direct current. Where direct current is used the alternating current must be changed to direct current. A motor generator set (alternating current motor driving a direct current generator) or a rectifier is used for this purpose. (See Figure 29).

## DIRECT CURRENT VS. ALTERNATING CURRENT

There are advantages and disadvantages in using both AC and DC current:

- Alternating current is more dangerous: 1/10 ampere of alternating current gives a fatal shock; however, it takes five times as much direct current (1/2 ampere) to give the same shock.
- The voltage of alternating current can be raised or lowered with very little loss in a simple transformer; changing direct current voltage requires complex electronic circuits.
- Direct current voltage can be lowered by passing it through a Rheostat, a resistance whose value can be changed; however, this procedure wastes power.
- The speed and power output of direct current motors can be adjusted and varied much more simply and efficiently than the speed and power output of alternating current motors.

Now go to the Questions and answer 59 through 70



## ELECTRIC MOTORS AND GENERATORS

The hoist motor changes electrical energy into rotary motion. The generator that supplies power to the hoist changes rotary motion into electricity. A generator may also be called a dynamo. Since there are differences between alternating current and direct current motors and generators, we will describe them separately.

Direct Current Motor: It has four principal parts: (See Figure 30)

- The field magnets which are mounted in the motor frame. The field magnets are electromagnets (that is, cores wrapped in coils of wire.)
- The armature which is the rotating part of the motor and mounted inside the motor frame. The armature consists of several electromagnets (cores with their coils) mounted on a shaft.
- The commutator which is a series of segments of a circle arranged around and attached to the armature shaft. Each segment is connected to one of the armature's electromagnet coils.
- The brushes are attached to the motor frame and touch the commutator. They provide a path for electricity from the power supply through the commutator to the electromagnet coils in the armature. (See Figure 31)

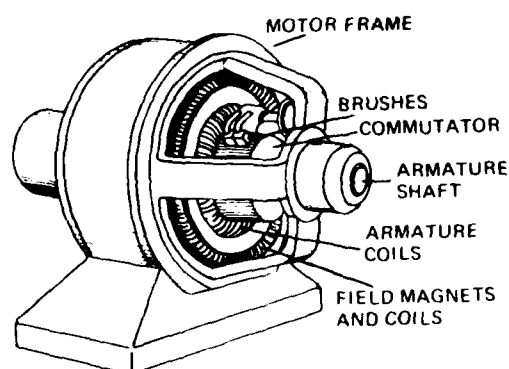


Figure 30

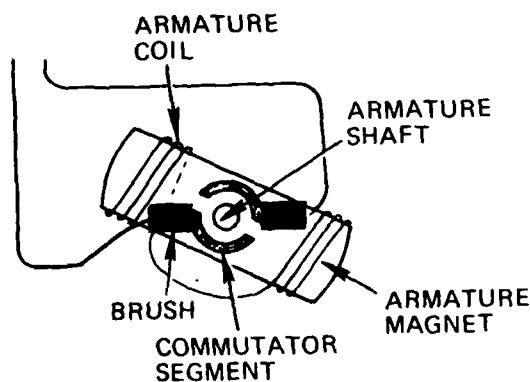


Figure 31

A Direct Current Motor operates on these principles:

- If we reverse the flow of current through the coil of an electromagnet, the poles of the magnet are reversed.
- Opposite poles attract each other.
- Like poles repel each other.

Industrial motors, like the one in Figure 30, have several armature magnets with two commutator segments for each one. They may also have more than one field magnet. In order to explain the operation of a direct current motor we will use a simple motor which has only these parts:

- One field magnet
- One armature magnet
- Two commutator segments

Note in Figures 32 through 34 that the poles of the field magnet do not change.

In Figure 32 the armature poles are the same. The nearest field poles, therefore, are being repelled, causing a clockwise rotation of the armature.

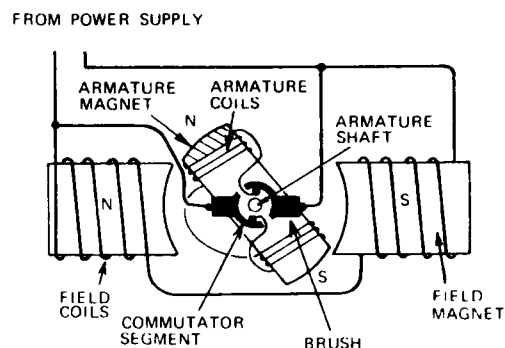


Figure 32

In Figure 33 the armature has continued its clockwise movement and the armature poles are being attracted by the opposite field poles.

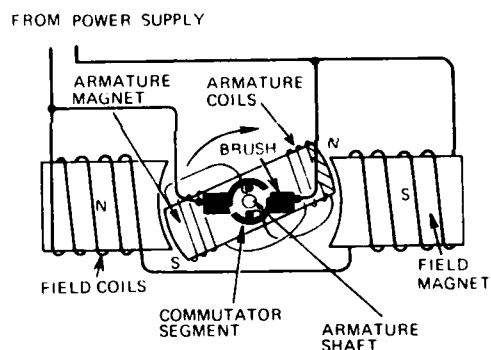


Figure 33

In Figure 34 the armature has passed through the horizontal position and the brushes have switched to opposite segments of the commutator. Current flow in the armature coils is reversed; the armature poles are reversed and are now being repelled by the field poles to continue the clockwise motion. The rotary motion of the armature can be used to turn the hoist drum, hydraulic pump and other machinery.

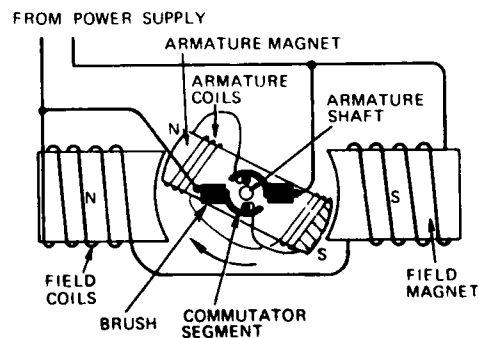


Figure 34

Increasing or decreasing the armature current will increase or decrease the magnetic forces which turn the armature and therefore, increase or decrease the power output of the motor. (See Figure 35) A direct current motor is reversed by changing the direction of current flow in either the armature or the field coils.

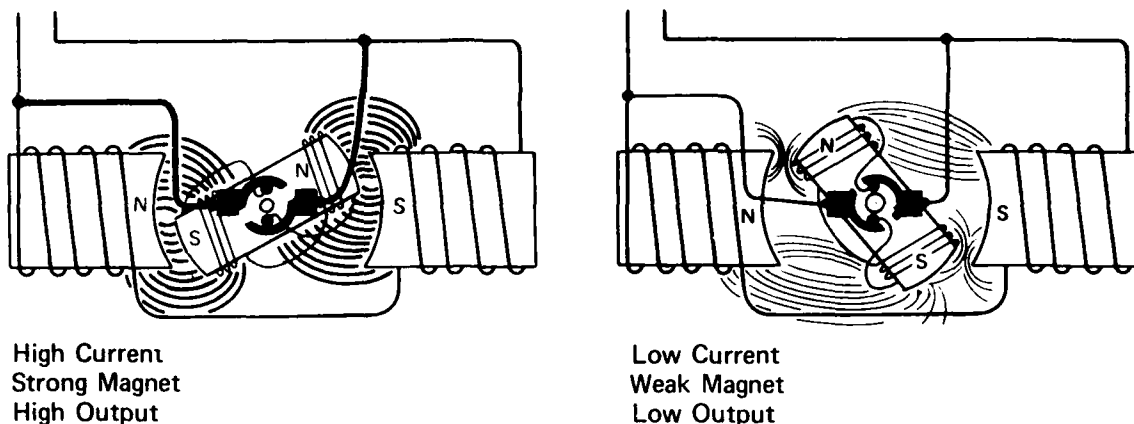


Figure 35

The brushes of a DC motor are made of either carbon or copper. Copper is a better conductor and wears longer. However, it is fairly hard and causes more wear on the motor commutator. Carbon brushes cause little commutator wear; however, they do chip and cause sparking, and they need to be replaced more often. Each brush usually has a wire (Pigtail) attached which is connected to the power supply.

The position of the brushes is very critical. If the voltage on the brush and the voltage of the commutator segment passing under the brush are not very nearly equal, sparking will occur. Changing position of the brush will help correct this defect. A worn commutator or broken brush will also cause sparking.

Now go to the Questions and answer 71 through 84

### DIRECT CURRENT GENERATOR

A direct current generator has the same parts as a direct current motor.

- Direct current from an outside source flows through the field coils.
- A power source, turbine, diesel or gasoline engine, or motor turns the armature.
- As the armature coils pass through the magnetic fields a voltage is generated in the coils. This causes current to flow in the coils.
- The current flows to the commutator and through the brush circuit to the machine, light or appliance where it will be used. (See Figure 36)

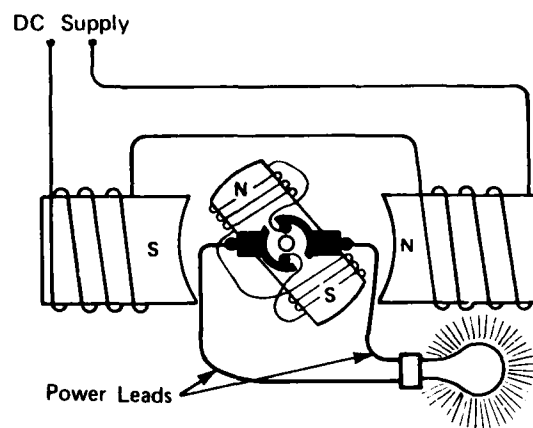


Figure 36

- Increasing the strength of the magnetic field and/or increasing the speed of the armature increases the generated voltage. (See Figure 37)

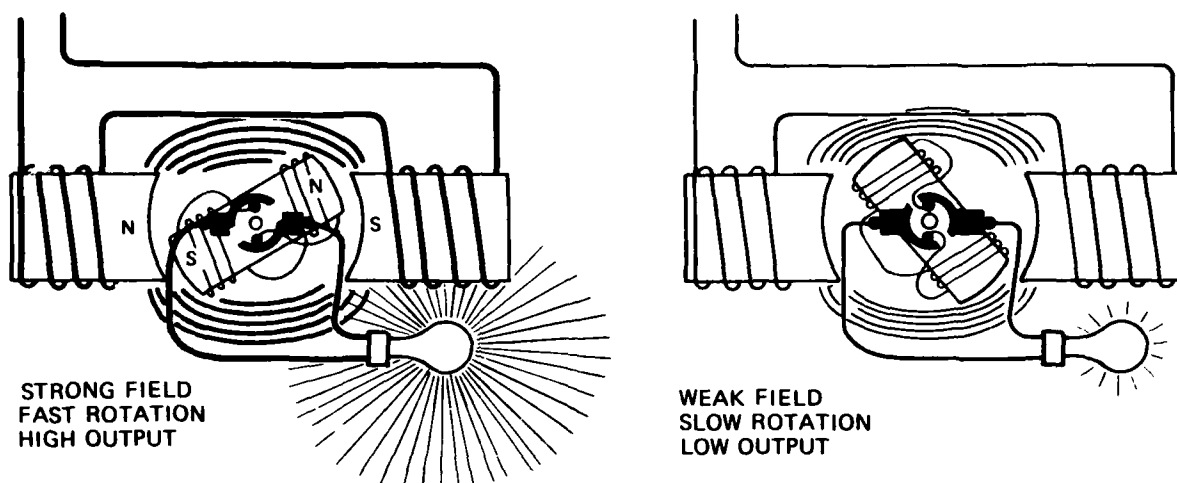


Figure 37

- The voltage generated in the coils reverses itself each time that it passes a different pole. This would cause alternating current to flow. (See Figure 38)

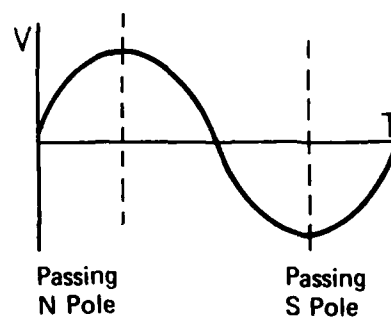


Figure 38

However, the commutator switches the end of the coils from one power lead to another as the voltage reverses itself. The switching keeps the voltage in the power leads going in the same direction. (See Figure 39)

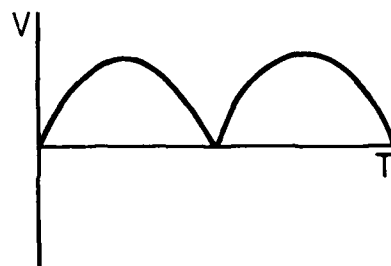


Figure 39

Industrial generators have many armature coils and the current flows into the power leads at peak voltage. The output has little more than a slight ripple. (See Figure 40)

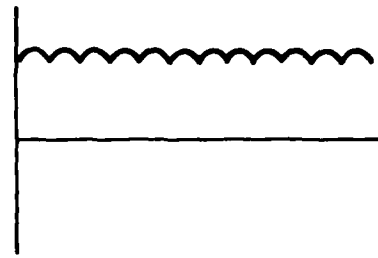


Figure 40

## ALTERNATING CURRENT GENERATOR

In a direct current generator a magnetic field was created in the field coils and voltage was generated in the armature coils. (See Figure 41)

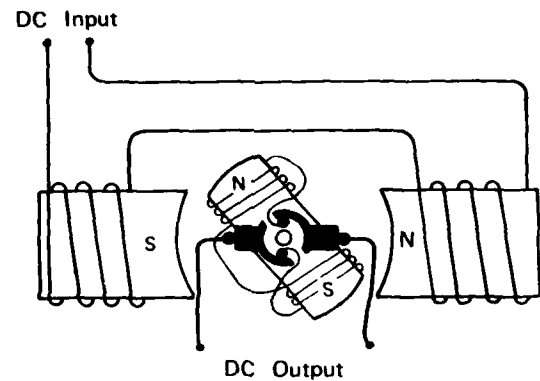


Figure 41

In an alternating current generator the magnetic field is created in the armature. DC current flows into the armature coils through slip rings. As the armature turns voltage is generated in the field coils. (See Figure 42)

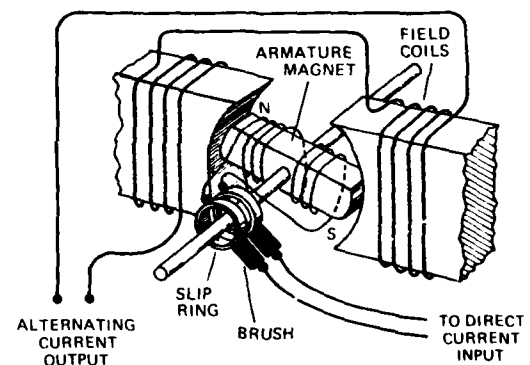


Figure 42

The output of a simple AC generator is shown in Figure 43.

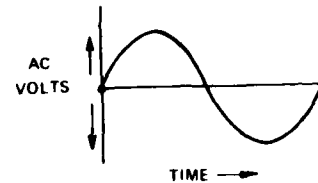


Figure 43

An industrial AC generator has 3 pairs of poles (See Figure 44). Each pair is independent of the other pairs. The output of each pair (Figure 44) is called a phase. The output of each phase is like Figure 43.

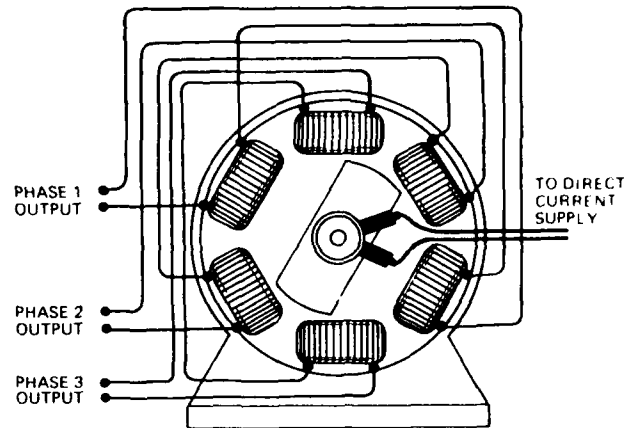


Figure 44

The output of the three phases looks like Figure 45.

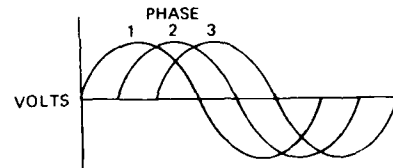


Figure 45

The stronger the magnetic field and the faster the armature rotation, the higher the voltage and current flow.

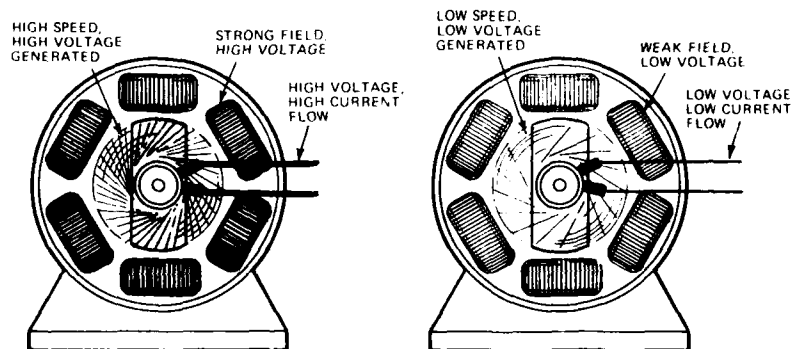


Figure 46

## ALTERNATING CURRENT MOTOR

An alternating current motor has a frame and field coils that are just like those of an alternating current generator (See Figure 44).

The coils of a large alternating current motor would be connected to the corresponding coils of the generator.

The voltage in the generator coils will cause current to flow through the motor coils and create magnetic fields. The fields will change poles successively and create a rotating field inside the motor frame. (See Figures 47A through D)

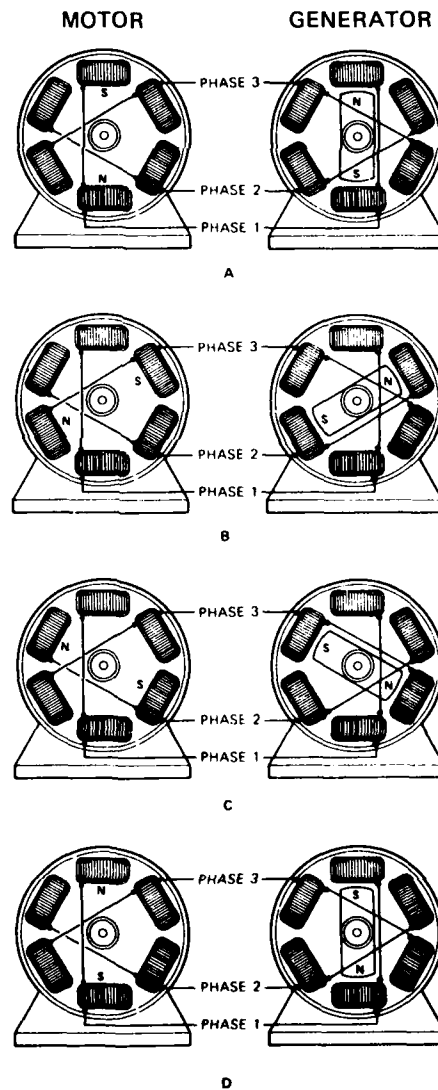


Figure 47

The armature of an alternating current motor is a core with a coil of wire. The ends of the coil are connected together. (See Figure 48)

As the motor field passes over the armature, a voltage is generated (or induced) in the armature coil, and current flows and creates a magnet. The magnet is attracted by the rotating field and rotates with it.

The voltage is induced in the armature coil only if the rotating field rotates faster than the armature does. The difference in armature rotation speed and field rotation speed is called Slip.

The more slip the more voltage is generated, and the stronger the armature magnet becomes. If the magnet is stronger, the motor rotates faster or with more force.

<u>Slip</u>	<u>Armature Voltage Generated</u>	<u>Armature Current Flow</u>	<u>Armature Magnet Strength</u>	<u>Power Output</u>
High	High	High	High	High
Medium	Medium	Medium	Medium	Medium
Low	Low	Low	Low	Low

Now go to the Questions and answer 85 through 94

### HOIST MOTOR SPEED CONTROL

The speed of a mine hoist motor needs to be controlled. The speed of the alternating current motor, like the direct current motor, depends on armature current. In a mine hoist AC motor, armature resistances are placed in the armature coil circuits. The resistances can be bypassed by closing switches. (See Figure 37)

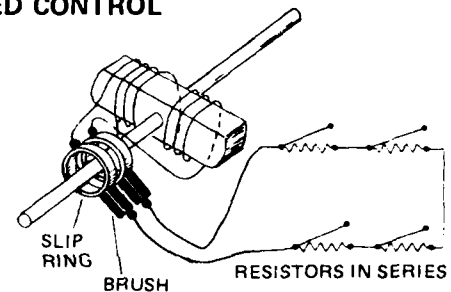


Figure 48

When starting the AC motor, all of the switches are open and the armature circuit has maximum resistance. At this time slip is at a maximum and the generated voltage is high. The high resistance keeps the armature current low. If the resistance were not in the circuit, the armature current might get too high and damage the motor.

As the armature picks up speed, slip, the voltage, and the current flow declines. The switches are closed, one by one, to allow additional current to flow through the armature coils. The armature continues to pick up speed until all of the switches are closed. The motor is then running at its best speed for the amount of work that it is doing.



To slow the armature the switches are opened one by one. This action:

- Increases the resistance of the armature circuit.
- Reduces the flow of current through the armature coils.
- Reduces the strength of the armature magnets.
- Causes the armature to slow down.

In a mine hoist the resistances are normally located in the hoist control room. The switches are in the hoist motor control box and are opened or closed by turning the motor controller. The switches and resistances are connected to the armature coils through slip rings and brushes.

Note that if we exchange the connections of two phases of the motor with two phases of the generator, the direction of rotation of the magnetic field will be reversed. This is how an AC motor is reversed.

### STARTING DIRECT CURRENT MOTORS

When the armature of a DC motor is turning, a voltage is generated in the armature coil as the coil passes through the motor's magnetic field. This voltage opposes the voltage from the power supply. The voltage causing current to flow in the armature coils is equal to the difference between the power supply voltage and that being generated in the armature coils.

When the armature is not turning all of the power supply voltage is causing current to flow. If the power supply voltage is too high, too much current will flow. Therefore, the voltage first applied to the armature should be low. It is increased slowly as the motor picks up speed and begins to generate the opposing voltage.

The motor is at full speed when the power supply voltage is at its maximum.

If the voltage to a running DC motor drops, the armature may slow down and stop. In this condition, there may be enough voltage remaining to force enough current through the armature to burn the armature coils.

The voltage to the armature in a mine hoist motor is increased or decreased by strengthening or weakening the magnetic field of the DC generator, or by changing the output voltage of the rectifier.

#### Types of Direct Current Motors

A Shunt motor is shown in Figure 49.

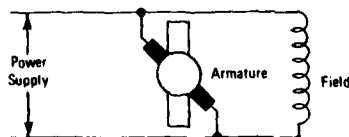


Figure 49

The field coil and armature (through the brushes) are both connected across the power supply. They are in parallel.

A Series motor is shown in Figure 50.

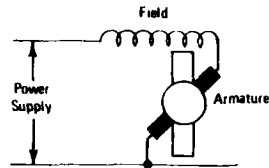


Figure 50

One terminal of the field coil is connected to one terminal of the armature. The two are then connected across the power supply. The armature and field coils are in series.

A Compound motor is shown in Figure 51.

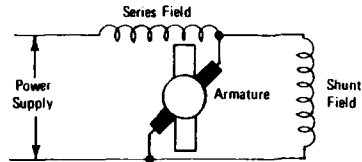


Figure 51

The motor has two fields, a shunt field and a series field. If the connections of the series field in a compound motor becomes reversed, as the motor starts it will rotate in one direction. As the armature current and the series field current increases, the series field will overpower the shunt field and cause the motor to reverse itself.

Now go to the Questions and answer 95 through 106

## HOIST OPERATION

Figure 52 shows a sample sketch of a mine hoist electrical system with an alternating current motor. It functions as follows:

- Alternating current power comes from the power company to the switch board and through the hoist power switch to the hoist control.
- The hoist control does two things:
  - It sends power to the alternating current motor fields, and
  - It controls the amount of resistance in the circuit that includes the armature coils and the resistor sets.
- When the hoist motor starts there is a high resistance in the armature and resistor circuit. The resistance is lowered as the motor picks up speed.

### ALTERNATING CURRENT HOIST MOTOR OPERATION

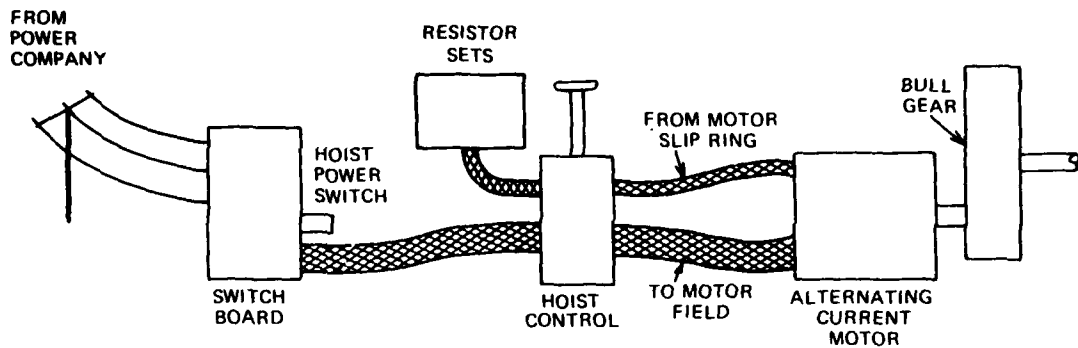


Figure 52

Figure 53 is a simple sketch of a mine hoist electrical system with a direct current hoist motor and a motor generator set. It functions as follows:

- Alternating current power from the power company goes to the switchboard and through the hoist power switch to the alternating current motor of the motor generator set.
- The alternating current motor drives the direct current generator and the exciter generator.

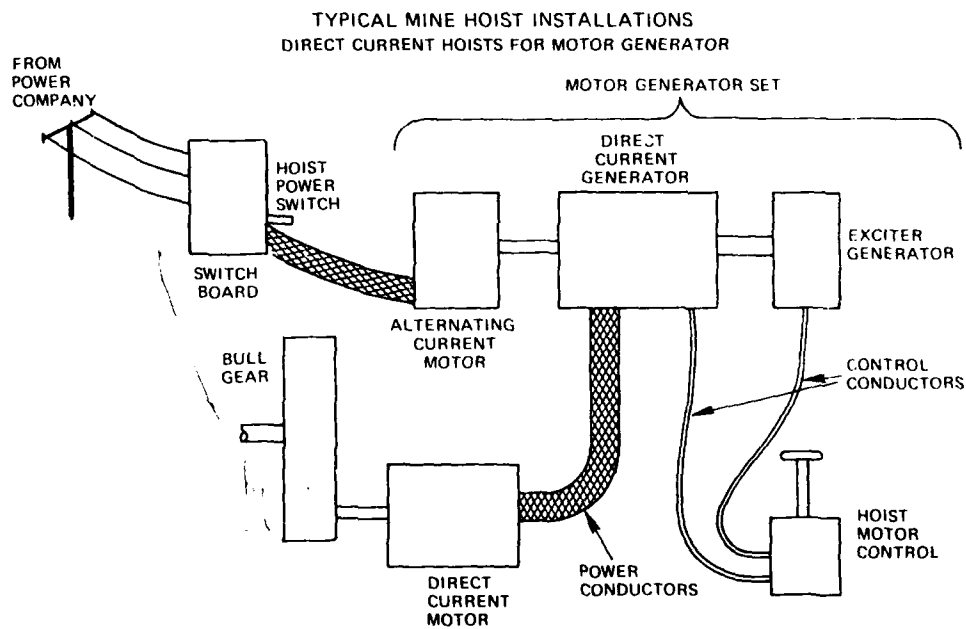


Figure 53

- The exciter generator is a small direct current generator that provides the current for the main generator magnetic fields.
- The output of the exciter generator goes to the hoist motor control then to the direct current generator fields.
- The hoist motor control is a switch that controls the direction and the amount of current that goes to the generator fields.
- The condition of the DC generator fields will determine the direction and amount of current that will be delivered to the hoist motor.
- The output of the main generator drives the hoist motor.

Figure 54 shows a simple sketch of a mine hoist electrical system with a direct current motor and a rectifier power supply. It functions as follows:

- Alternating current power goes through the switchboard to the hoist power switch, then to the rectifier.
- The rectifier changes the alternating current to direct current.
- The hoist motor control causes the rectifier to send current at the required voltage and in the proper direction to the hoist motor.

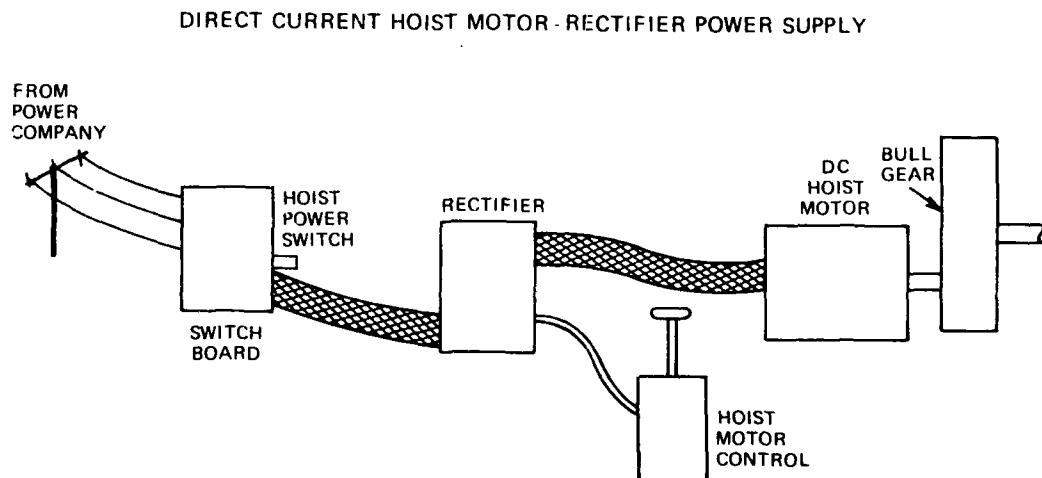


Figure 54

## USING THE MOTOR AS A BRAKE

An electric motor may be used as a brake to control the speed of the machine that it drives. This feature may be used in a mine hoist, for example, to slow the conveyance when lowering a heavy load and when approaching the designated landing.

In a direct current motor the armature voltage is reduced below that of the opposing voltage being generated in the motor armature. The overall voltage then is forcing current to flow out of the motor armature rather than into it. In effect, the motor is now a generator. The energy required to generate the current acts as a brake on the motor armature and causes it to slow. The current that flows back can be sent back to the power company through the motor generator.

In some alternating current motors the motor is simply reversed. When lowering, for example, the hoist motor control is placed in the hoist position. The rotating field starts to rotate in the opposite direction and will slow the rotation speed of the armature.

In other alternating current motors, a switch is provided to substitute direct current for alternating current in one or two of the phases. Voltage is then generated in the armature coils as they rotate in the newly created magnetic field. The voltage is absorbed in the starting resistances. The energy thus absorbed acts as a brake on the motor armature.

The use of the motor as a brake is sometimes referred to as Dynamic Braking.

Now go to the Questions and answer 107 through 111

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## TRANSFORMERS

The relationships between electricity and magnetism are used in another electrical machine called a "transformer." The transformer changes the voltage of alternating current. If it raises the voltage it is a step-up transformer. If it lowers the voltage it is a step-down transformer.

You might ask "Why do we want to change the voltage?" We want to change voltage because for some applications high voltage is preferred and for others, low voltage. For example, transmission losses are lower if electric power is transmitted at high voltage and low current (we covered that in a previous section). However, at the point where electricity is used, that is, generated and/or handled, this high voltage is more dangerous than low voltage. (Remember that voltage is the pressure causing current to flow.) High pressure/voltage may cause current to flow in places where it is not wanted, such as between poorly insulated conductors or from conductors to the machinery frame. High voltage may also cause sparking on motor commutators. It may also be a source of fire or damage to motors, heaters, lights, controls and other equipment. Therefore, it is safer and more economical to have low voltage where the power is generated and used, and to have high voltage where power is transmitted.

Here is what the inside of a transformer looks like. (Figure 55)

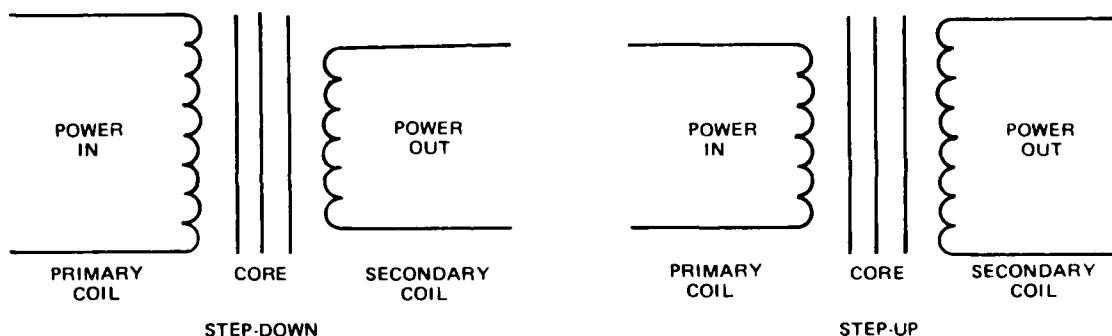


Figure 55

A transformer consists of two coils with a common core. Alternating current flows into the primary coil in one direction and makes a magnet out of the core. The build up of magnetism in the core causes a voltage to be generated in the secondary coil. As the current reverses itself in the primary coil, the magnet is reversed and causes a reverse voltage to be generated in the secondary coil. Thus, the alternating current flowing into the primary coil generates a voltage which causes current to flow in the secondary coil.

Since power losses in a transformer are very small, for the purpose of this explanation we will consider them to be zero, the power flowing into the primary coil ( $P_p$ ) is equal to the power flowing out of the secondary coil ( $P_s$ ).

The voltage going into the primary coil ( $E_p$ ) and the voltage going out of the secondary coil ( $E_s$ ) are proportional to the number of turns of wire in each coil ( $N_p$  for the primary and  $N_s$  for the secondary). Suppose we have a transformer like this one, Figure 56.

**Primary**  
 $P_p$  - Power = 1000 Watts  
 $N_p$  - Turns = 100  
 $E_p$  - Volts = 100  
 $I_p$  - Amperes = ?

**Secondary**  
 $P_s$  - Power = ?  
 $N_s$  - Turns = 10  
 $E_s$  - Volts = ?  
 $I_s$  - Amperes = ?

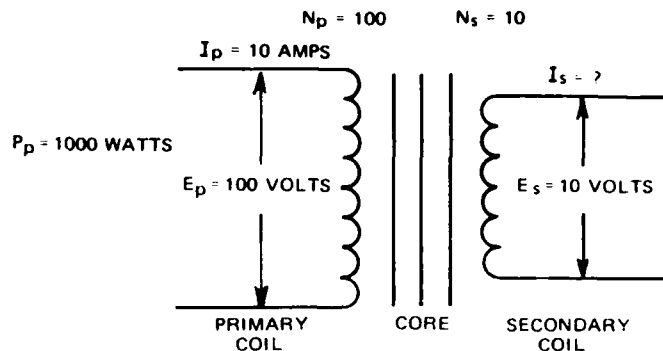


Figure 56

Since we know the power and volts into the primary, and the number of turns in both the primary ( $N_p$ ) and secondary ( $N_s$ ), we can solve for the unknown values. For example, Primary current ( $I_p$ ):

1000 watts going into the primary at 100 volts;

$$P_p = E_p \times I_p; P_p = 1000; E_p = 100$$

$$\text{Then; } I_p = \frac{P_p}{E_p} = \frac{1000}{100} = 10$$

Secondary Power ( $P_s$ )

Since there are 1000 watts of power going into the primary  $P_p$ , there must be approximately 1000 watts of power from the secondary  $P_s$ .

$$\text{Secondary Voltage (} E_s \text{) } P_p = P_s; P_s = 1000 \text{ watts}$$

Since there are 100 volts and 100 turns in the primary  $E_p$  and  $N_p$ , and 10 turns in the secondary  $N_s$ ,

$$\frac{E_p}{N_p} = \frac{E_s}{N_s} \text{ or}$$

$$\frac{100}{100} = \frac{E_s}{10} \text{ or } E_s = \frac{100}{100} \times 10 = 10 \text{ volts.}$$

Secondary Current ( $I_s$ )

Since there are 1000 watts of power in the primary ( $P_p$ ), there are also (for our purpose) 1000 watts in the secondary ( $P_s$ ).

$$P_p = P_s = 1000 \text{ watts.}$$

Also  $P_s = E_s \times I_s$  or

$1000 = 10 \times I_s$  or

$I_s = \frac{1000}{10} = 100 \text{ amperes.}$

In summary then, remember these relationships about transformers

$P_p = P_s$  (approximately)

Therefore:  $E_p \times I_p = E_s \times I_s$

$\frac{E_p}{N_p} = \frac{E_s}{N_s}$

### Use of Laminations

The magnetizing and demagnetizing that occur in transformers, motors and generators cause stray currents, called eddy currents, to flow through the magnet itself. The power that is used by this current flow ( $I^2 \times R$ ) comes from the power supply and is a loss.

In order to reduce these losses to a minimum the cores for electric motor and generators and for transformers are not made of solid iron. Instead they are made of thin, soft iron plates (laminations), stacked together and insulated from each other, usually by insulating varnish (See Figure 57). The laminated construction reduces the flow of the eddy currents.

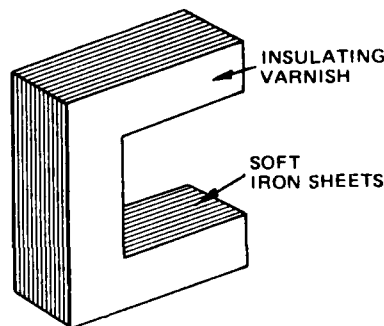


Figure 57

Now go to the Questions and answer 112 through 118



## **ELECTRICAL SAFETY**

Electricity can be dangerous if not properly controlled.

If electrical machinery is used near flammable materials, vapors, or gases, sparks may be given off and cause a fire.

If the current flowing through a conductor is greater than the conductor can carry safely, the conductor may overheat and cause a fire or otherwise damage the machines.

If just 1/10 of an ampere passes through your body the shock could kill you.

Federal safety regulations require that steps be taken to prevent such accidents. Basic requirements are as follows:

Electrical machinery that is used in mines and other areas where flammable dust, gas, or vapors may be present must be enclosed. This will prevent sparks, such as occur on motor commutators, switches, and at loose connections, from igniting the flammable materials.

Every electrical circuit must use conductors that are large enough to carry the normal current flow of the circuit, plus an acceptable overload without overheating. For most circuits a 25% overload is allowed. The circuit must also have a fuse or circuit breaker (automatic switch) that will interrupt the current flow if the normal load plus the overload is exceeded.

## **OVER CURRENT PROTECTION**

Electrical equipment and conductors can only carry a limited amount of current without being damaged. Fuses or circuit breakers prevent too much current from flowing through the conductors or through the equipment.

### **FUSE**

A fuse is a piece of metal that is placed in the circuit, in series with the load. When too many amperes flow through the fuse the heat generated ( $I^2 \times R$ ) causes the metal to melt and breaks the circuit. A new fuse must be installed to restore power.

### **CIRCUIT BREAKER**

A circuit breaker is a magnetic switch that is also placed in the circuit, in series with the load. When too much current flows through the conductors, the magnetic switch opens and stops the flow. The circuit breaker may then be reset, that is, the switch closed and the circuit re-energized.

Conductors supplying power to a mine or other facility are protected by circuit breakers or fuses, before they enter the mine. In addition, a very large fuse or circuit breaker (lightning arrester) is installed to break the circuit if lightning strikes the power lines. A ground wire is also provided to lead the lightning to ground.

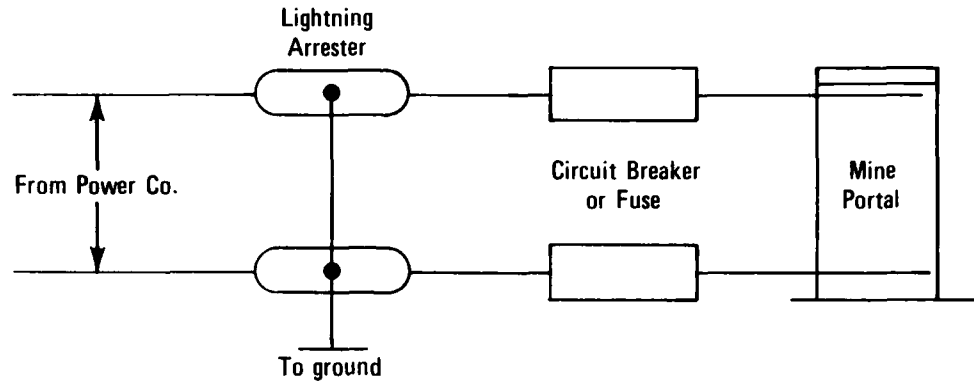


Figure 58

## ELECTROLYSIS

When an electric current flows through a mixture of water and dissolved metallic compounds, that is, iron oxide (rust), corroded metal, clay, etc., chemical changes take place. Oxygen and hydrogen may be generated, and metals with which the current comes in contact may be eroded away and deposited elsewhere. This action can severely damage metal structures that are in contact with the moist material. Good grounding of all equipment can help to keep the voltage difference between the structures to a minimum and reduce the possibility of damage. (See Figure 59)

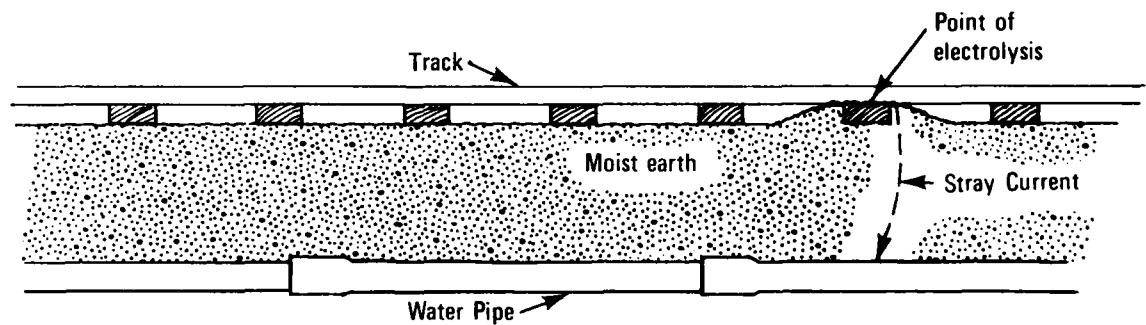


Figure 59

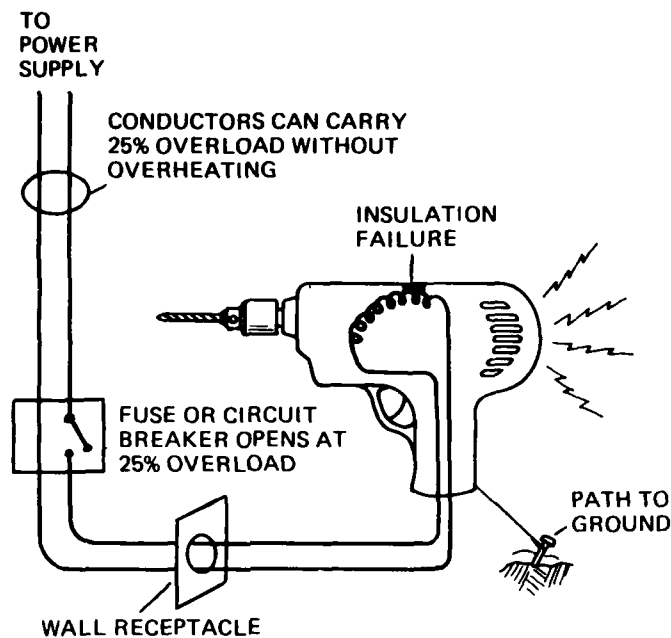


Figure 60

Conductors and other current-carrying parts of the machines shall be insulated or enclosed to prevent persons from touching them. In addition, some areas restrict the maximum voltage permitted on exposed conductors such as trolley wires. Illinois restricts the voltage to 275 volts.

Exposed metal parts of electrical machinery that do not carry current normally, the frames, stands, enclosures, must be connected to the ground. Normally, the conductors and parts of electrical machines through which the current flows are insulated from the frames and other structural parts of the machines. If the insulation is damaged these parts may carry current. If a person touches one of the current carrying parts, his/her body will provide a path for the current to flow to the ground. The person will receive a shock and may be killed. The ground connection provides a path for current to flow to the ground. Thus, if a break occurs in the insulation, current will flow to ground in sufficient quantity to open the overcurrent protection device.

### DE-ENERGIZING EQUIPMENT

Prior to having personnel work on electrical equipment, the power shall be cut off from that equipment and measures taken to prevent its being turned back on until the work is completed. A typical measure is to lock the switch box closed, hand a sign on the box stating, **DO NOT CLOSE SWITCH**, and give the key to the person working on the equipment.

Now go to the Questions and answer 119 through 132

## PRACTICE QUESTIONS FOR THE ELECTRICAL SYSTEM

Answer the following questions by filling in the blanks or solving the problems.

1. Voltage is \_\_\_\_\_ causing flow of \_\_\_\_\_ .
2. Current is the rate of flow of \_\_\_\_\_ .
3. A unit of voltage is \_\_\_\_\_ .
4. A unit of current is \_\_\_\_\_ .
5. A \_\_\_\_\_ is a path through which electricity will flow from the \_\_\_\_\_ voltage to the \_\_\_\_\_ voltage point.
6. The symbol for volts is \_\_\_\_\_ .
7. The symbol for amperes is \_\_\_\_\_ .
8. If a \_\_\_\_\_ is put in the path of the electrons, the rate of flow of electrons will be reduced.
9. The unit of resistance to flow in an electrical circuit is \_\_\_\_\_ .
10. The symbol for resistance is \_\_\_\_\_ .
11. Ohm's Law is the relationship between the number of \_\_\_\_\_ , \_\_\_\_\_ and \_\_\_\_\_ .
12. The symbols  $E=IR$  stand for: volts = \_\_\_\_\_ X \_\_\_\_\_ .
13. Ohms =  $\frac{\text{volts}}{\text{amperes}}$  can also be written as \_\_\_\_\_ =  $\frac{E}{I}$ .
14.  $I = \frac{E}{R}$  is the same as amperes = \_\_\_\_\_ .
15. If there are 10 amperes flowing through a circuit with 20 ohms resistance, what is the voltage? \_\_\_\_\_
16. If there are 200 volts across a 5 ohm resistance, how many amperes are there?  
\_\_\_\_\_
17. If 50 volts cause 10 amperes to flow in a circuit, what is the resistance in the circuit?  
\_\_\_\_\_
18. Find the current flow in a 240 volt series circuit with 5 resistances:  $R_1 = 9$ ;  $R_2 = 7$ ;  $R_3 = 20$ ;  $R_4 = 18$ ;  $R_5 = 6$ .  
\_\_\_\_\_  
The current flow is \_\_\_\_\_ .

19. Find the current flow in a 120 volt parallel circuit with 2 resistances:  $R_1 = 12$ ;  $R_2 = 8$ .

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

The current flow is \_\_\_\_\_.

20. Substances that have a low resistance to electricity are called \_\_\_\_\_.
21. Substances that have a high resistance to electricity are called \_\_\_\_\_ and are used as \_\_\_\_\_.
22. The conductor with the least resistance is \_\_\_\_\_; a commonly used conductor with high resistance is \_\_\_\_\_.
23. Other good conductors are \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
24. Some commonly used non-conductors are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and some plastics.
25. The perfect conductors are \_\_\_\_\_; the perfect non-conductors are \_\_\_\_\_.
26. Most conductors are in the form of a copper or aluminum wire; the diameter of the wire is measured in \_\_\_\_\_.
27. The area of wire that is 3/1000 of an inch is measured as 3 \_\_\_\_\_.
28. Current is measured with a/an \_\_\_\_\_.
29. Voltage is measured with a/an \_\_\_\_\_.
30. The ability of a motor or engine to do work is called \_\_\_\_\_.
31. A hoist exerts one foot pound per second of power if it lifts one pound \_\_\_\_\_ foot in \_\_\_\_\_ second.
32. To find the power of an engine in foot pounds per second use the formula:  
Power = \_\_\_\_\_.
33. If a hoist lifts 100 pounds 2 feet in 5 seconds, \_\_\_\_\_ foot pounds per second of power are used.

34. To determine the amount of work done by a motor, the formula "Work = \_\_\_\_\_" can be used or "Work = \_\_\_\_\_ X Seconds."
35. If 6 pounds are lifted 2 feet, \_\_\_\_\_ foot pounds of work are done.
36. A common term to express the power of a motor is \_\_\_\_\_.
37. One horsepower is the power needed to do \_\_\_\_\_ foot pounds of work in one second or \_\_\_\_\_ foot pounds of work in one minute.
38. If a hoist has a 200 horsepower motor, it could do \_\_\_\_\_ foot pounds of work in one second.
39. In one minute a 200 horsepower motor could lift a 33,000 pound weight \_\_\_\_\_ feet.
40. How many horsepower are needed to run the hoist if 30,000 pounds of ore are to be lifted at a speed of 1,100 feet per minute (Ignore friction losses). \_\_\_\_\_  
\_\_\_\_\_
41. \_\_\_\_\_ for electrical machinery is usually measured in watts.
42. One horsepower is equal to \_\_\_\_\_ watts.
43. The power of a 10 horsepower motor can be expressed as \_\_\_\_\_ watts.
44. A kilowatt is equal to \_\_\_\_\_ watts.
45. If a 15 kilowatt machine operates for one hour, it does \_\_\_\_\_ kilowatt hours of work.
46. To calculate the electric power that is used, multiply the voltage by the current flow, or  $P =$  \_\_\_\_\_.
47. If 200 volts cause 10 amperes to flow in a circuit, the power used is \_\_\_\_\_ watts or \_\_\_\_\_ kilowatts.
48. If 600 watts are used for 3 hours, \_\_\_\_\_ watt hours of work are done.
49. A \_\_\_\_\_ meter measures work that is done by an electrical machine.
50. Power used when current flows through conductors or resistance can be calculated by using  $P = E \times I$  and replacing E with its formula  $E =$  \_\_\_\_\_. The formula becomes:  $P =$  \_\_\_\_\_.

51. If there are 10 amperes flowing through a circuit with 5 ohms resistance, the power used in the circuit is \_\_\_\_\_ watts.
52. Heat from current flowing through the resistance in conductors creates two problems: \_\_\_\_\_ in transmission from power company to the customer and possible \_\_\_\_\_.
53. Electricity is usually transmitted at very high \_\_\_\_\_ and low \_\_\_\_\_ since line losses increase very rapidly as current is increased.
54. The formula \_\_\_\_\_ helps to explain line losses and safety hazards.
55. The heat from lost power could ignite \_\_\_\_\_ and start a fire or could burn the \_\_\_\_\_ of a conductor.
56. A fire hazard is created when there is a poor connection, too small \_\_\_\_\_ or a damaged \_\_\_\_\_ between the power supply and the load that creates additional \_\_\_\_\_.
57. Poor connections and damaged conductors normally \_\_\_\_\_ resistance.
58. Suppose a motor draws 15 amperes at a normal load. If the conductor to the switch box has a bad connection, how many watts of power per ohm of resistance are lost and turn to heat? \_\_\_\_\_.
59. Direct current electricity flowing through a wire coil wrapped around an iron core will cause the iron core to become a \_\_\_\_\_.
60. The upper pole of an electromagnet is a North pole; if we reverse the direction of current flow in the coil the upper pole will be a \_\_\_\_\_ pole.
61. The strength of the magnetic field is increased if the number of \_\_\_\_\_ or the \_\_\_\_\_ is increased.
62. Like poles \_\_\_\_\_ each other; unlike poles \_\_\_\_\_ each other.
63. A wire passing through a magnetic field has a voltage generated that will cause current to flow from right to left. If we reverse the direction of motion of the wire and reverse the positions of the North and South poles, the generated voltage will cause current to flow from \_\_\_\_\_ to \_\_\_\_\_.
64. When a wire passes through a magnetic field the voltage is \_\_\_\_\_ as the wire enters the field; the voltage is at a \_\_\_\_\_ at the center of the field; the voltage is \_\_\_\_\_ as it leaves the field.

65. The voltage of \_\_\_\_\_ electricity causes the current to flow in one direction only.
66. The voltage of \_\_\_\_\_ electricity causes the current to flow in one direction, then the other.
67. \_\_\_\_\_ current is more dangerous than \_\_\_\_\_ current.
68. It is easier to change \_\_\_\_\_ current voltage because it can be raised or lowered in a simple transformer.
69. Direct current voltage can be lowered by passing it through a/an \_\_\_\_\_ ; This procedure wastes \_\_\_\_\_ .
70. It is easier to adjust and vary the speed and output of \_\_\_\_\_ current motors than the speed and output of \_\_\_\_\_ current motors.
71. An electric motor changes electrical energy into \_\_\_\_\_ ; a generator changes \_\_\_\_\_ into electrical energy.
72. Another name for a generator is \_\_\_\_\_ .
73. List the four principal parts of a direct current electric motor.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
74. An electric motor operates on these principles;  
Reversing the flow of current through the coil of an electromagnet \_\_\_\_\_  
the poles of the magnet.  
Opposite poles \_\_\_\_\_ each other.  
Like poles \_\_\_\_\_ each other.
75. When the brushes of a direct current motor change commutator segments, the \_\_\_\_\_  
\_\_\_\_\_ in the armature coil is \_\_\_\_\_ .
76. Increasing the armature current \_\_\_\_\_ the magnetic forces which \_\_\_\_\_  
the armature.
77. Power output of the motor is \_\_\_\_\_ by decreasing the armature current.



78. Direct current motors can be reversed by changing the direction of current flow in either \_\_\_\_\_ or \_\_\_\_\_.
79. A DC motor has brushes made of either \_\_\_\_\_ or \_\_\_\_\_.
80. \_\_\_\_\_ brushes are hard and cause wear on the motor commutator;  
\_\_\_\_\_ brushes cause little commutator wear.
81. \_\_\_\_\_ brushes chip and cause sparking; \_\_\_\_\_ is a better conductor and wears longer.
82. A wire which is connected to each brush and the power supply is called \_\_\_\_\_.
83. Changing \_\_\_\_\_ will help correct sparking.
84. A broken brush or a worn commutator may cause \_\_\_\_\_.
85. In a direct current generator, direct current from an outside source flows through the \_\_\_\_\_.
86. The voltage generated in a direct current generator increases as the \_\_\_\_\_ of the field and \_\_\_\_\_ of the armature increase.
87. In a direct current generator the current generated in the armature coil is changed from \_\_\_\_\_ current to \_\_\_\_\_ current as it passes through the \_\_\_\_\_.
88. In an alternating current generator direct current flows into the \_\_\_\_\_ coils; alternating current is generated in the \_\_\_\_\_ coils.
89. The output voltage from each pair of field coils is called a/an \_\_\_\_\_. Each \_\_\_\_\_ is independent of the other two phases.
90. In an alternating current motor a/an \_\_\_\_\_ magnetic field is created within the motor frame.
91. The ends of the armature coils of an alternating current motor are \_\_\_\_\_.
92. The current flow through the armature coils of an alternating current motor is caused by a/an \_\_\_\_\_ voltage.
93. Slip is the difference between the speed of rotation of the \_\_\_\_\_ and the \_\_\_\_\_.

94. An alternating current motor has a high power output when the slip is \_\_\_\_\_ .
95. The speed of direct current motors and alternating current motors is controlled by changing the current flow in the \_\_\_\_\_ .
96. The resistors and switches in the armature circuit of an alternating current motor are used to control \_\_\_\_\_ in the armature coil.
97. The resistance in the armature coil circuit of an alternating current motor is least when the armature rotates at \_\_\_\_\_ speed.
98. Applying full voltage to a direct current motor armature that is stopped can \_\_\_\_\_ .
99. The voltage that causes current to flow in a direct current motor armature is equal to the power supply voltage \_\_\_\_\_ the voltage generated in the armature.
100. If the hoist motor is powered by a motor generator set the motor control adjusts the \_\_\_\_\_ in the generator field.
101. If the armature of a running DC motor slows and stops because of a voltage drop, voltage may force enough current through the armature to \_\_\_\_\_ .
102. Two ways to increase or decrease the voltage to the armature in a DC mine hoist motor are 1. \_\_\_\_\_ or \_\_\_\_\_ the field voltage of the DC Generator; and 2. change the \_\_\_\_\_ of the rectifier.
103. The three types of DC motors are \_\_\_\_\_ , \_\_\_\_\_ and \_\_\_\_\_ .
104. A \_\_\_\_\_ motor has two fields.
105. A \_\_\_\_\_ motor has the field coil and the armature in parallel; they are both connected across the power supply.
106. A \_\_\_\_\_ motor has one terminal of the field coil connected to one terminal of the armature; the two are then connected across the power supply.
107. A small direct current generator that provides current for the main generator magnetic fields is the \_\_\_\_\_ .
108. To use a direct current motor as a brake the voltage to the motor armature is \_\_\_\_\_ .

109. One method of using an alternating current motor as a brake is to \_\_\_\_\_ the rotating field.
110. A second method of using an alternating current motor as a brake is to substitute \_\_\_\_\_ in one or two of the phases.
111. \_\_\_\_\_ is a term for using the motor as a brake.
112. A \_\_\_\_\_ changes the voltage of alternating current.
113. A \_\_\_\_\_ transformer raises the voltage; a \_\_\_\_\_ transformer lowers the voltage;
114. It is more economical and safer to have high voltage where power is \_\_\_\_\_ and to have low voltage where power is \_\_\_\_\_.
115. The basic operating principles of a transformer are:
- Transformer has a/an \_\_\_\_\_ coil, a/an \_\_\_\_\_ coil and a common \_\_\_\_\_.
  - AC current flows in the primary coil and makes a/an \_\_\_\_\_ of the core.
  - The build up of magnetism causes a voltage to be generated in the \_\_\_\_\_.
  - As the current reverses itself in the primary coil, the magnet is reversed and causes a reverse voltage to be generated in the \_\_\_\_\_.
  - Therefore, the alternating current flowing into the \_\_\_\_\_ generates a voltage which causes current to flow in the \_\_\_\_\_.
  - The power flowing into the primary coil ( $P_p$ ) is \_\_\_\_\_ to the power flowing out of the secondary coil ( $P_s$ ).
  - The voltage going into the primary coil ( $E_p$ ) and the voltage going out of the secondary coil ( $E_s$ ) are proportional to the \_\_\_\_\_ in each coil,  $N_p$  for the primary and  $N_s$  for the secondary.
116. Suppose there is a transformer like the one below. Find the unknown values.
- | Primary                          | Secondary                        |
|----------------------------------|----------------------------------|
| $P_p = 1200$                     | $P_s = \underline{\hspace{2cm}}$ |
| $N_p = 200$                      | $N_s = 60$                       |
| $E_p = 200$                      | $E_s = \underline{\hspace{2cm}}$ |
| $I_p = \underline{\hspace{2cm}}$ | $I_s = \underline{\hspace{2cm}}$ |
117. The cores for electric motors and generators and transformers are made of \_\_\_\_\_, which are soft iron plates stacked together and insulated from each other.

118. The flow of eddy currents is \_\_\_\_\_ by a laminated construction.
119. A fire could be caused by \_\_\_\_\_ used near electrical machinery that sparks.
120. A conductor may overheat and cause a fire or damage machines if the current flowing through the conductor is \_\_\_\_\_ .
121. Federal regulations for mines require that electrical machinery used where flammable dust, gas or vapors may be present must be \_\_\_\_\_ .
122. Conductors that are large enough to carry the normal circuit \_\_\_\_\_ , plus an acceptable \_\_\_\_\_ (25%) without overheating must be used in all circuits.
123. Federal regulations require electrical circuits to have a \_\_\_\_\_ or \_\_\_\_\_ to interrupt the flow of current if it gets too high.
124. The voltage difference between metal structure in moist areas can be reduced by \_\_\_\_\_ all equipment.
125. A piece of metal placed in the circuit in series with the load to prevent over current flow is a/an \_\_\_\_\_; too many amperes flowing through this metal generate \_\_\_\_\_ which melts it and breaks the circuit.
126. A magnetic switch placed in the circuit in series with the load to prevent over current flow is called a/an \_\_\_\_\_; when too much current flows through the conductors, this switch opens and \_\_\_\_\_ .
127. A large fuse or circuit breaker installed to break the circuit if lightning strikes the power line is called a/an \_\_\_\_\_; a/an \_\_\_\_\_ is also provided to lead lightning to the ground.
128. Chemical changes from an electric current flowing through a mixture of water and dissolved metallic compounds are called \_\_\_\_\_ .
129. The maximum voltage permitted on exposed conductors is restricted by the state of Illinois to \_\_\_\_\_ watts.
130. If insulation on a conductor is damaged, current should be able to flow to the ground through a/an \_\_\_\_\_ connection.

131. Before personnel work on electrical equipment, \_\_\_\_\_ must be cut off from the equipment and \_\_\_\_\_ taken to prevent its being turned back on until work is completed.
132. One way to prevent power from being returned to equipment during repair work is to lock the \_\_\_\_\_ closed, hang a \_\_\_\_\_ sign on the box, and give the \_\_\_\_\_ to person working on equipment.

## ANSWERS TO PRACTICE QUESTIONS

1. pressure; electrons
2. electrons
3. volt
4. ampere
5. conductor; high; low
6. E
7. I
8. resistance
9. ohm
10. R
11. volts, amperes; ohms
12. amperes; ohms
13. R; I
14.  $\frac{\text{volts}}{\text{ohms}}$
15. 200 volts  $E = 10 \times 20$
16. 40 amperes  $200 = I \times 5 = \frac{200}{5} = I$
17. 5 ohms  $50 = 10 \times R \frac{50}{10} = R$
18.  $I = \frac{E}{R+R+R+R+R} = \frac{240}{9+7+20+18+6} = \frac{240}{60} = 4$   
4 amperes
19.  $I_T = I_1 + I_2 = 10 + 15 = 25$   
 $I_1 = \frac{120}{12} = 10 \text{ amperes}$   
 $I_2 = \frac{120}{8} = 15 \text{ amperes}$   
25 amperes

20. conductors
  21. nonconductors; insulators
  22. silver; carbon
  23. gold, copper, aluminum
  24. rubber, porcelain, glass
  25. none; none
  26. mils
  27. circular mils
  28. ammeter
  29. voltmeter
  30. power
  31. one; one
  32.  $\frac{\text{Pounds X Feet}}{\text{Seconds}}$
  33.  $\frac{100 \times 2}{5} = \frac{200}{5} = 40$
  34. Pounds X Feet; Power
  35. 12
  36. horsepower
  37. 550; 33,000
  38.  $550 \times 200 = 110,000$
  39. 200
  40. 1000 horsepower
- Work = Pounds X Feet = Work =  $30,000 \times 1,100 = 33,000,000$  foot pounds.
- Power =  $\frac{33,000,000}{33,000} = 1,000$
41. Power
  42. 746

43. 7460
44. 1000
45. 15
46.  $E \times I$
47.  $P = 200 \times 10 = 2000$ ; 2
48. 1800
49. watt hour
50.  $I \times R$ ;  $I^2 R$
51.  $P = 10 \times 10 \times 5 = 500$
52. loss of power; fire hazard
53. voltage; amperage
54.  $P = I^2 R$
55. flammable materials; insulation
56. a conductor; conductor; resistance
57. increase
58.  $P = I^2 \times R = 15 \times 15 \times 1 = 225$  watts
59. magnet
60. South
61. wire turns; current flow
62. repel; attract
63. right; left
64. low; peak; low
65. direct current
66. alternating current
67. Alternating; direct
68. alternating



- 69. rheostat; power
- 70. direct; alternating
- 71. rotary motion; rotary motion
- 72. dynamo
- 73. brushes  
armature  
commutator  
field magnets
- 74. reverses; attract; repel
- 75. current flow or voltage; reversed
- 76. increases; rotate
- 77. decreased
- 78. the armature; the field coils
- 79. carbon; copper
- 80. Copper; carbon
- 81. Carbon; copper
- 82. a pigtail
- 83. the position of the brush
- 84. sparking
- 85. field coils
- 86. strength; speed
- 87. alternating; direct; commutator
- 88. armature; field
- 89. phase; phase
- 90. rotating
- 91. connected
- 92. induced
- 93. rotating field; armature

- 94. high
- 95. armature
- 96. current flow
- 97. high
- 98. cause damage
- 99. less or minus
- 100. current flow
- 101. burn the armature coils
- 102. strengthen; weaken; output voltage
- 103. shunt; series; compound
- 104. compound
- 105. shunt
- 106. series
- 107. exciter generator
- 108. reduced
- 109. reverse
- 110. direct current
- 111. Dynamic braking
- 112. transformer
- 113. step-up; step-down
- 114. more economical; safer; transmitted; generated and used
- 115.
  - A. primary; secondary; core
  - B. magnet
  - C. secondary coil
  - D. secondary coil
  - E. primary coil; secondary coil
  - F. about equal
  - G. number of turns of wire

116.	<u>Primary</u>	<u>Secondary</u>
	6 amperes	1200
		60 volts
		20 amperes

$$\text{Primary: } P_p = E_p \times I_p \quad 1200 = 200 \times I_p \quad \frac{1200}{200} = I_p \quad I_p = 6$$

$$\text{Secondary: } \frac{E_p}{N_p} = \frac{E_s}{N_s} \quad \frac{200}{200} = \frac{E_s}{60} \quad \frac{200}{200} \times 60 = 60 \text{ volts}$$

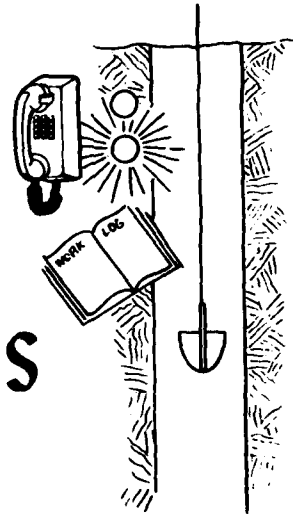
$$P_s = E_s \times I_s \quad 1200 = 60 \times I_s \quad I_s = \frac{1200}{60} = 20 \text{ amperes}$$

- 117. laminations
- 118. reduced
- 119. flammable materials
- 120. too great
- 121. enclosed
- 122. current flow; overload
- 123. fuse; circuit breaker
- 124. grounding
- 125. fuse; heat
- 126. circuit breaker; stops the flow
- 127. lightning arrester; ground wire
- 128. electrolysis
- 129. 275
- 130. ground
- 131. power ; measures
- 132. switch box; DO NOT CLOSE SWITCH; key

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 21

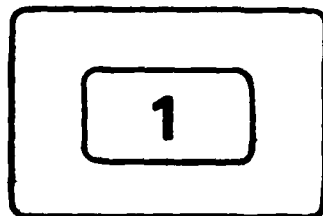
# BEGINNING OF SHIFT ACTIVITIES



## OBJECTIVE

The trainee will be able to assure  
that the hoist is in proper operating condition.

## TIME



## **TRAINING OBJECTIVES FOR BEGINNING OF THE SHIFT ACTIVITIES**

The trainee will be able to explain in writing each of the five tasks the hoist operator performs at the beginning of the shift.

Given a list of mine hoist parts and a list of possible defects, the trainee will be able to match each part to its possible defects.

The trainee will be able to answer multiple-choice questions about the procedure for grease lubrication.

Given an illustration of an oil flow or oil reservoir system, the trainee will be able to write the procedures for lubricating with each system.

The trainee will be able to answer multiple-choice questions about:

1. operating the conveyance the full length of the shaft
2. logging

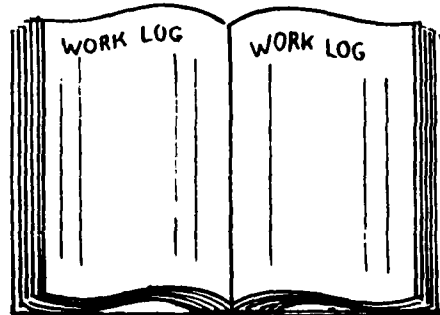
Given an illustration of the control panel, the trainee will be able to write the procedure for testing power to the hoist.

Given an illustration of each of the safety devices, the trainee will be able to write the procedures for testing the operation of that device.

At the beginning of a shift, the hoist operator has five basic tasks to perform to assure that the hoist is ready to operate:

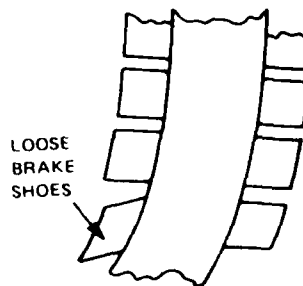
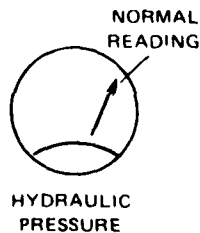
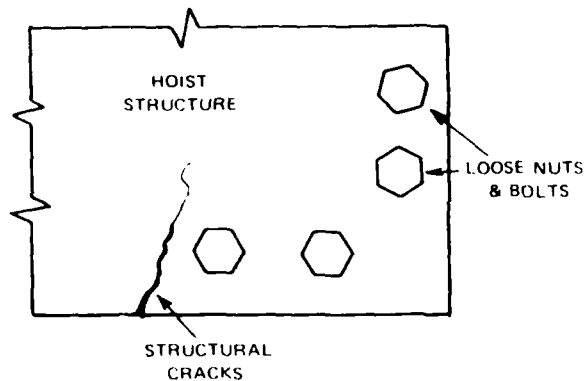
1. Check the general condition of the hoist
2. Check the hoist parts for proper lubrication
3. Check the power supply to the hoist
4. Operate the hoist the full length of travel
5. Check the operation of the safety devices

The first task the hoist operator does is to find out the general condition of the hoist. To do this she/he will:



- Find out what happened on the previous shift:
  - Read log
  - Talk to previous operator

- Visually inspect for defects, such as:
  - Hoist anchorage, structure, and drum: loose bolts and nuts, structural cracks
  - Brakes: abnormal hydraulic or pneumatic pressure, loose shoes or worn bands
  - Wiring: frayed, insulation, loose connections
  - Hoist rope: loose couplings on conveyance and safety cables, no slack in safety cable, needs lubrication.

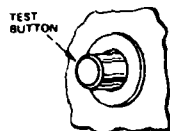
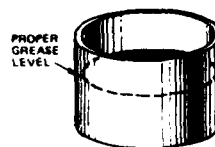


The next task a hoist operator does when he/she comes on shift is to assure that lubrication is provided to the points that require it.

In Unit 16 various lubrication systems were described. Here is how the hoist operator will use them to assure that the hoist is properly lubricated.

For installed grease systems, he/she will:

- Inspect grease supply in reservoir



- Test the system operation

- Inspect for grease at the lubrication points
- Request assistance if necessary.

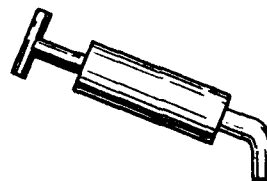
Record activities in the log.

INSPECT FOR GREASE  
AT LUBRICATION POINTS



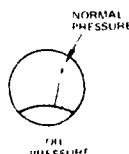
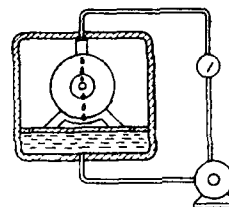
With a portable grease gun the hoist operator will:

- Inspect for grease at points to be lubricated
- Lubricate where necessary.



For a hoist with an oil flow system he/she will:

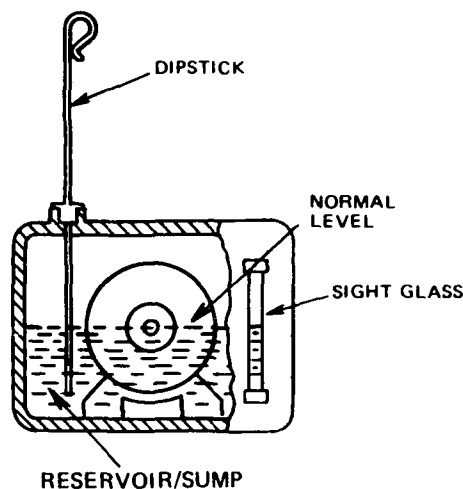
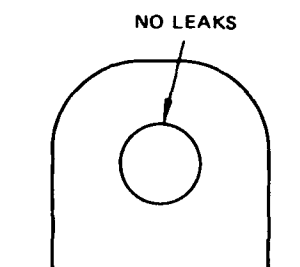
- Inspect oil supply in reservoir
- Inspect pump (look at pressure gauge)
- Inspect for leaks
- Inspect sight glass for normal oil flow
- Request assistance if necessary



Record activities in the log.

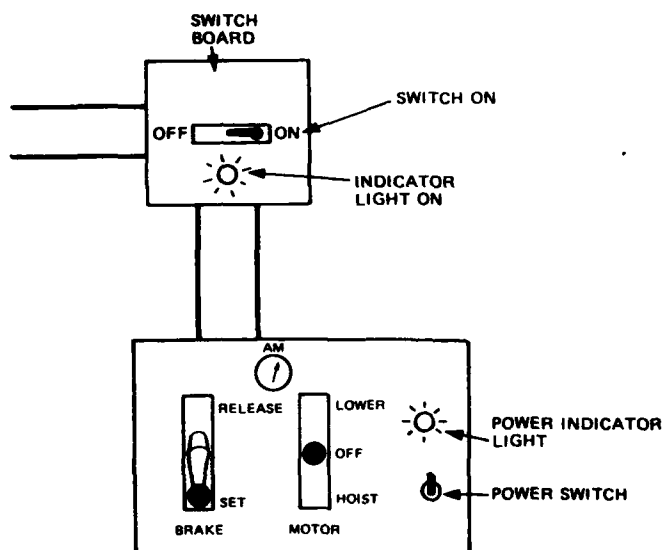
For hoists with an oil reservoir system he/she will:

- Inspect oil supply in reservoir
- Inspect bearings for leaks
- Request assistance if necessary



Record activities in the log.

The third task the hoist operator performs is to assure that power is available to all parts of the hoist. The power is controlled by switches. If the switch is **CLOSED**, power flows through the switch and is **ON**. If the switch is **OPEN**, power cannot flow through the switch and is **OFF**.



To assure that power is available to the switchboard the hoist operator will:

- Close the main power switch on the switchboard (turn power **ON**.)
- Note if the indicator light is **ON**.

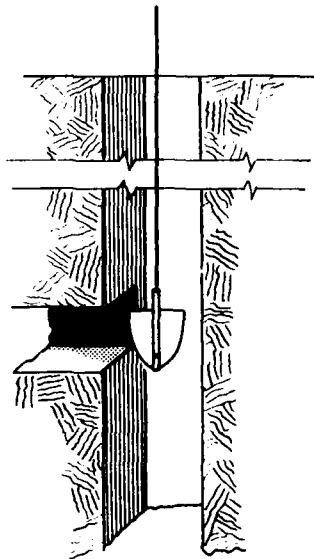
To assure that power is available to the hoist control stand:

- Close the power switch on the control stand (turn power **ON**.)
- Move the motor control in one direction
  - Note deflection of ammeter
- Move the motor control in the other direction
  - Note deflection of ammeter
- Request assistance if test fails.

Record activities in the log.



The next task the hoist operator does is to run an empty conveyance at slow speed the full length of the shaft. This is done to assure that the shaft is clear and that the controls operate properly. Often an inspector rides in the skip or cage and he/she looks for abnormalities in the shaft. The specific procedure for operating the hoist is in the unit "Routine Shift Activities."

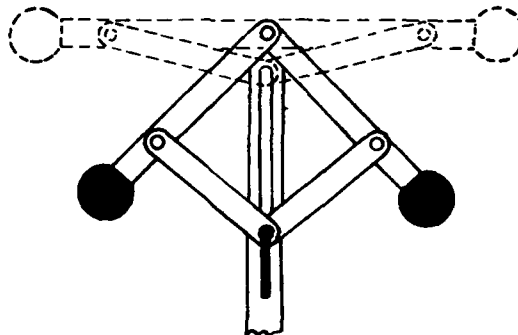


Another task to be performed at the beginning of the shift is to test the hoist safety devices. If a device fails its test, it must be repaired before starting operations. The results of these tests must be recorded in the log. These tests may be performed by the hoist operator or by maintenance personnel.

#### Overspeed Cutout Switch

The overspeed cutout switch is built into the Lilly, Simplex or other safety controller. To test the functioning of this device:

- Set the brake and stop the hoist
- Manually raise the weights on the governor
- Check to see that the main power switch opens (power turns **OFF**)
- Close the main power switch if it opens satisfactorily, otherwise have it repaired.

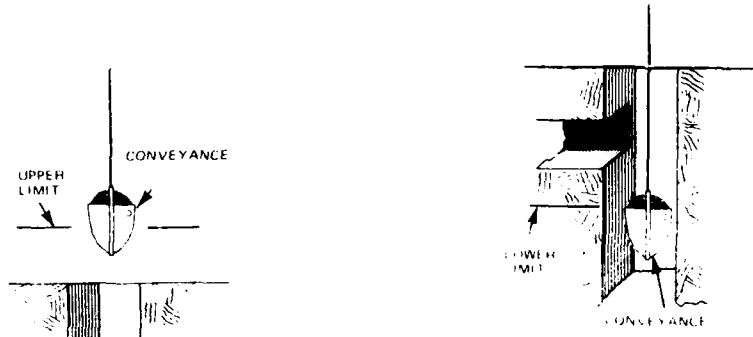


### Overtravel Cutout Switches

There are two cutout or limit switches to prevent overtravel, one at each end of the shaft. The switch near the top prevents the conveyance from traveling too far above the collar; the switch near the bottom prevents travel too far below the deepest landing.

To test the cutouts, the hoist operator will:

- move the conveyance slowly above/below the collar/deepest landing. The main power switch should open and the brakes should be set as the conveyance crosses the cutout level.

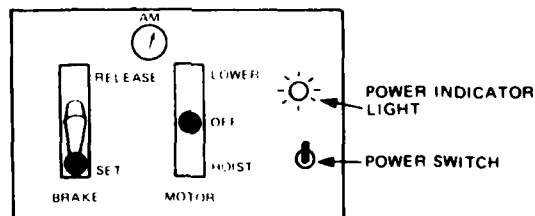


If the main power switch opens the hoist operator will:

- Set the brake and put the motor control on OFF
- Close the overtravel bypass switch
- Return the conveyance to the normal operating area

If the main power switch does not open, the hoist operator will:

- Set the brake
- Put the motor control on OFF
- Request assistance.

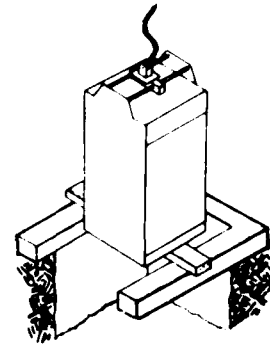


On some hoists, the safety controller also has an overtravel cutout switch. On such hoists the safety controller must be bypassed in order to test the shaft overtravel switches.

### Slack Rope Switch and Conveyance Safety Dogs

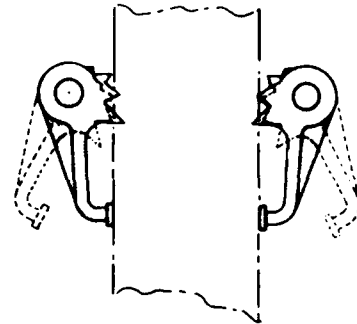
The slack rope switch will cut off power to the hoist and apply the drum brakes if the rope goes slack. To test the switch the hoist operator will:

- Support the conveyance. The support may be wood/metal beams or chains
- Slack the hoist rope



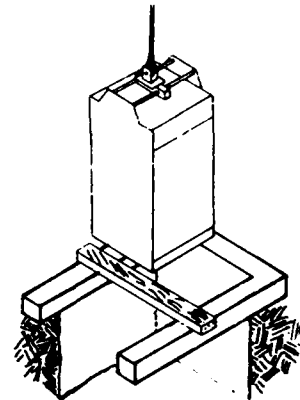
As the rope goes slack:

- The main power switch should open
- The safety dogs should begin to clamp on the shaft guide.



If the test is successful:

- Set brake
- Put motor control on OFF
- Close slack rope bypass switch
- Raise conveyance slowly until it is lifted off the supports if beams were used
- Remove the supports.

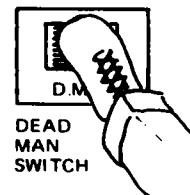


If the test fails, request assistance

### Deadman Switch

Most hoists are equipped with a "deadman switch." The switch is normally open and cuts off power to the hoist. The purpose of the switch is to remove power from the hoist and apply the brakes if something should happen to the hoist operator (has a heart attack, drops dead or becomes ill). The switch may be located on the floor or on the side of the hoist control stand. The operator closes the switch by standing on it, or by pressing his/her knee or leg against it.

To test the deadman switch, the operator tries to apply power to the hoist with the switch open. (He/she is not standing on it or pressing against it.) If power is applied, the switch is not working properly and must be repaired.

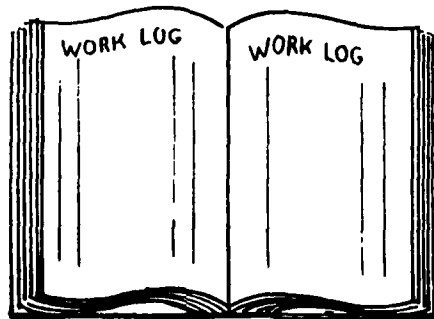


Each hoist is different. The above safety devices are required by law but there may be additional safety devices in your mine. You must learn what they are and how to test them. This will be done in Parts II and III.

### Logging

Federal regulations require that complete records be kept of installation, lubrication, inspection, tests, and maintenance of shafts and hoisting equipment. Your mine will have specific rules for making log entries in agreement with these regulations.

In Parts II and III you will learn what entries to make in the log and the format for making each.



## PRACTICE QUESTIONS FOR BEGINNING OF SHIFT ACTIVITIES

1. At the beginning of each shift the hoist operator performs five tasks to assure that the hoist is ready to operate. List the five tasks.
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_
  - E. \_\_\_\_\_
2. To determine the general condition of the hoist, the hoist operator finds out what happened on the previous shift by \_\_\_\_\_ and \_\_\_\_\_.
3. The hoist operator visually inspects the parts listed below. Write the defects he/she checks for.
  - A. Hoist anchorage, structure and drum — \_\_\_\_\_  
\_\_\_\_\_
  - B. Brakes — \_\_\_\_\_  
\_\_\_\_\_
  - C. Wiring — \_\_\_\_\_  
\_\_\_\_\_
  - D. Hoist rope — \_\_\_\_\_  
\_\_\_\_\_
4. To assure that the hoist with an installed grease system is lubricated properly, the hoist operator will:
  - A. Inspect the \_\_\_\_\_ in the reservoir
  - B. Test the system \_\_\_\_\_
  - C. Inspect for grease at \_\_\_\_\_
  - D. Request \_\_\_\_\_ if necessary.
5. To assure that a hoist with an oil flow system is lubricated properly, the hoist operator will:
  - A. Inspect the \_\_\_\_\_ in the reservoir
  - B. Inspect the pump by looking at \_\_\_\_\_
  - C. Inspect for \_\_\_\_\_
  - D. Inspect the sight glass for \_\_\_\_\_
  - E. Request \_\_\_\_\_ if necessary.

6. To assure that a hoist with an oil reservoir system is lubricated properly, the hoist operator will:
  - A. Inspect the \_\_\_\_\_ in the reservoir
  - B. Inspect \_\_\_\_\_ for leaks
  - C. Request \_\_\_\_\_ if necessary.
7. To assure that power is available to the hoist controls, the hoist operator closes the \_\_\_\_\_. If the indicator light doesn't come on, he/she requests \_\_\_\_\_.
8. The hoist operator moves the motor control in both directions and notes the deflection of the \_\_\_\_\_. If there is no deflection, he/she requests \_\_\_\_\_.
9. The empty conveyance is run at slow speed the full length of the shaft to assure that the shaft is \_\_\_\_\_ and that the controls \_\_\_\_\_.
10. To test the overspeed cutout switch: The hoist operator or maintenance personnel will:
  - A. Stop the \_\_\_\_\_ and set the \_\_\_\_\_.
  - B. Manually raise the \_\_\_\_\_ on the governor.
  - C. Check to see that the main power switch \_\_\_\_\_.
  - D. Close the main power switch if it \_\_\_\_\_ satisfactorily, otherwise have it \_\_\_\_\_.
11. There are two cutout or limit switches to prevent overtravel, one at each \_\_\_\_\_.
12. To test the overtravel cutout switches, the hoist operator will:
  - A. Move the conveyance slowly above/below the \_\_\_\_\_.
  - B. Check to see that the main power switch \_\_\_\_\_ when the conveyance reaches each limit. If the switch is operating properly, it will \_\_\_\_\_, and the brakes will be \_\_\_\_\_.
13. If the switch opens, the hoist operator will:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_

14. If the overtravel cutout switch doesn't open, the hoist operator will:
- A. Set the \_\_\_\_\_.
  - B. Put the motor control on \_\_\_\_\_.
  - C. Request \_\_\_\_\_.
15. The slack rope switch will cut off \_\_\_\_\_ and apply the \_\_\_\_\_ if the rope goes slack.
16. To test the slack rope switch the hoist operator will:
- A. Support the \_\_\_\_\_.
  - B. Slack the \_\_\_\_\_.
  - C. Check to see that when the rope goes slack, the main power switch \_\_\_\_\_.
  - D. Check the safety dogs; they should have begun to \_\_\_\_\_.
17. If the main power switch opens:
- A. Set the \_\_\_\_\_.
  - B. Put the motor control on \_\_\_\_\_.
  - C. \_\_\_\_\_ the bypass to the slack rope cutout switch.
  - D. If beams were used, hoist slowly until the conveyance is \_\_\_\_\_ off the supports.
  - E. Remove the \_\_\_\_\_.
18. The deadman switch is normally open and cuts off power \_\_\_\_\_.
19. The operator closes the deadman switch by \_\_\_\_\_ or by pressing \_\_\_\_\_.
20. To test the deadman switch, the operator tries to apply power to the hoist when the switch is \_\_\_\_\_ that is, when he/she does not have a knee or foot pressing against it.
21. If power is applied, the switch is \_\_\_\_\_.
22. If any of the safety devices fails its test, it must be \_\_\_\_\_ before starting operations.
23. Complete records of \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ of shafts and hoisting equipment will be kept in logs.

## ANSWERS TO BEGINNING OF THE SHIFT PRACTICE QUESTIONS

1.
  - A. Check general condition of hoist
  - B. Check hoist parts for proper lubrication
  - C. Check power supply to hoist
  - D. Operate hoist full length of travel
  - E. Check operation of safety devices
2. reading the log; talking to previous operator.
3.
  - A. loose nuts and bolts, structural cracks
  - B. abnormal hydraulic or pneumatic pressure, loose shoes or worn bands
  - C. loose connections, frayed insulation
  - D. loose coupling on conveyance and safety cables, needs lubrication, no slack in safety cable
4.
  - A. grease supply
  - B. operation
  - C. the lubrication points
  - D. assistance
5.
  - A. oil supply
  - B. the pressure gauge
  - C. leaks
  - D. normal oil flow
  - E. assistance
6.
  - A. oil supply
  - B. bearings
  - C. assistance
7. power switch; assistance.
8. ammeter; assistance.
9. clear; operate properly
10.
  - A. hoist; brake
  - B. weights
  - C. opens
  - D. opens; repaired
11. end of the shaft
12.
  - A. collar/deepest landing.
  - B. opens; open; applied
13.
  - A. Set the brake and put the control on OFF.
  - B. Close the overtravel cutout bypass switch.
  - C. Return the conveyance to the normal operating area.

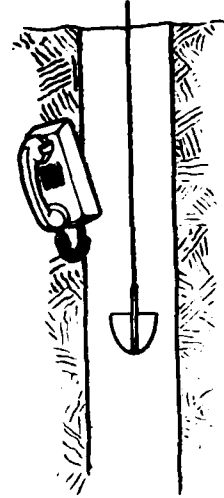


- 14. A. brake  
B. OFF  
C. assistance
- 15. power to the hoist; drum brakes
- 16. A. conveyance  
B. hoist rope  
C. opens  
D. clamp on the shaft guides
- 17. A. brake  
B. OFF  
C. close  
D. lifted  
E. supports
- 18. to the hoist
- 19. standing on it; his/her knee or leg against it
- 20. open
- 21. not working
- 22. repaired
- 23. installation, lubrication, inspection, tests, and maintenance

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 22

### ROUTINE SHIFT ACTIVITIES



#### OBJECTIVE

The trainee will know the routine hoisting activities  
that are performed during the shift

#### TIME

2

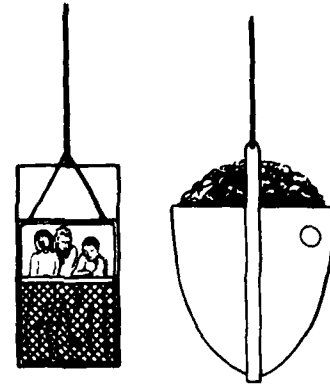
## **TRAINING OBJECTIVES FOR ROUTINE SHIFT ACTIVITIES**

**The trainee will be able to describe the procedures for moving the conveyance.**

- 1. The trainee will be able to answer in writing multiple-choice questions concerning procedures for moving the conveyance.**
- 2. Given a list of hoisting procedures for moving the conveyance, the trainee will be able to number the steps in the order they are performed.**

The hoist operator's basic job is to move the conveyance(s) from one level to another quickly and safely:

- The conveyances may be carrying men or materials into or out of the mine, or
- The conveyances may be carrying ore or waste out of the mine.



The conveyance is moved in five steps.

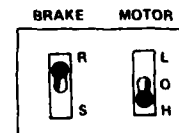
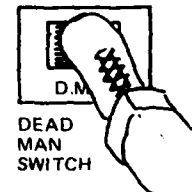
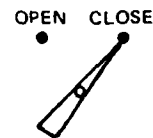
Figure 1 summarizes the five steps. For each step it indicates the hoist operator's action, the controls used, the conveyance movement, and the indicators noted.

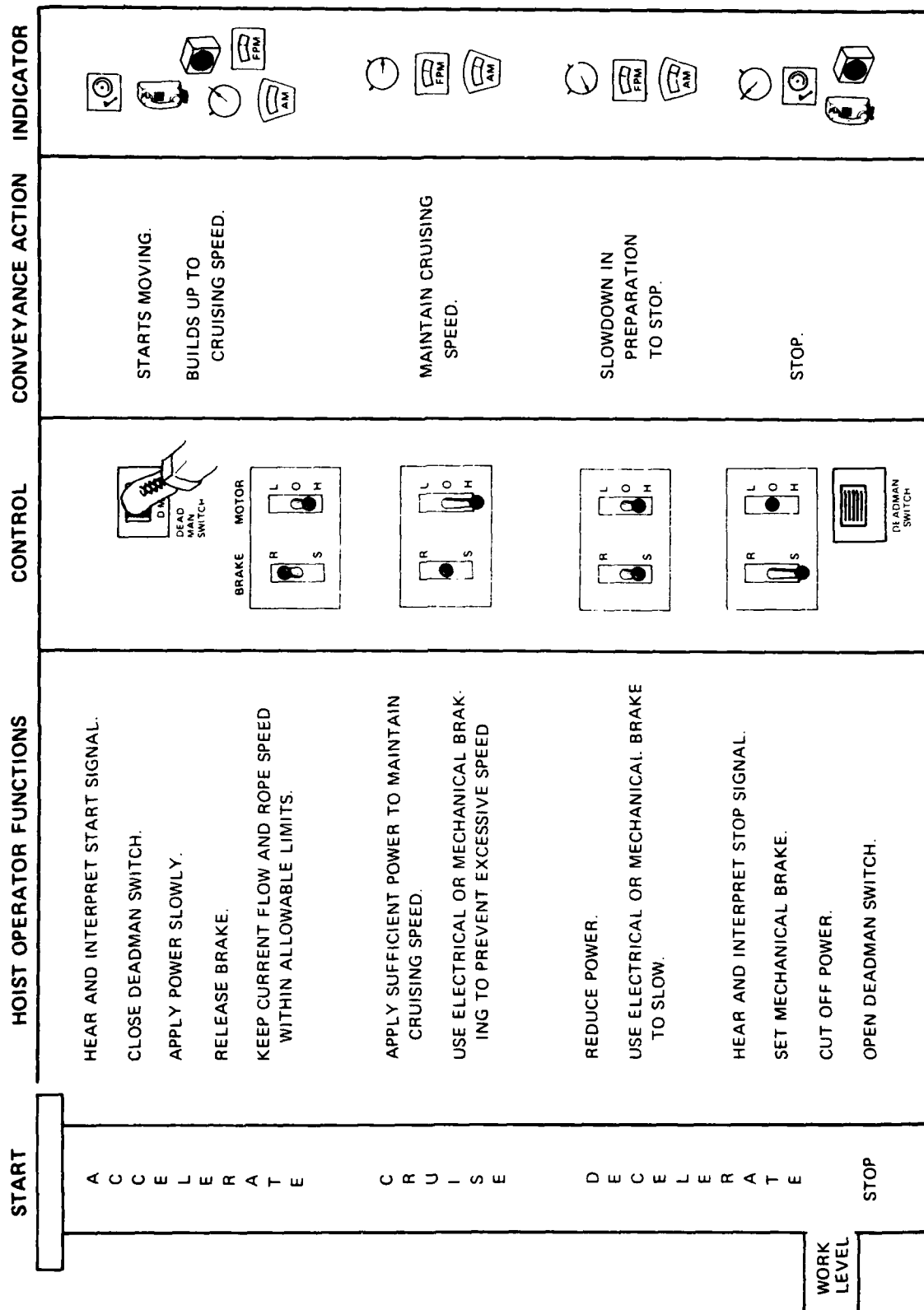
The steps are:

- Start
- Accelerate
- Cruise
- Decelerate
- Stop

Start Conveyance Moving:

- Receive and interpret the signal to start the hoist moving.
- Close the deadman switch bypass if materials, ore, or waste is the load.
- Close the deadman switch if people are the load.
- Apply power slowly and release the brake.

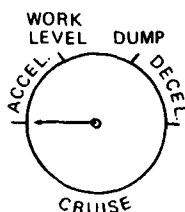




WORK  
LEVEL

Figure 1: Summary—Conveyance Moving Activities

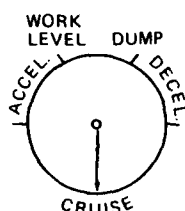
### Accelerate to Cruising Speed:



- Increase power to build up speed.
- Adjust the motor control to keep the current flow and the rope speed within the allowable limits.



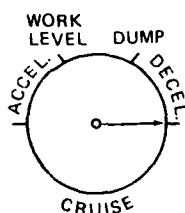
### Cruising:



- Use the motor control, electrical braking, or the mechanical or hydraulic brake to prevent excessive conveyance speed.
- Watch the rope speed meter, depth indicator and ammeter.



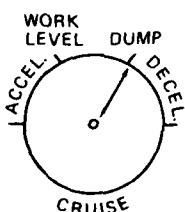
### Deceleration



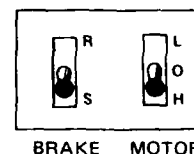
- Reduce power and speed when the conveyance reaches the point where it should be slowed to allow for a smooth stop. Watch the rope speed meter and depth indicators.



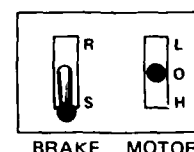
### Stop:

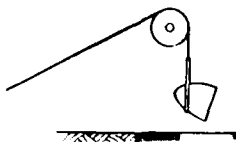


- Bring the conveyance to a very slow speed as it approaches the destination. Watch the markings on the drum or depth indicator closely.



- Set the brake and cut off power when the signal to stop is received.





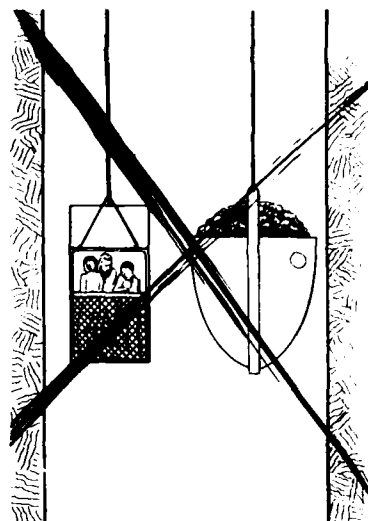
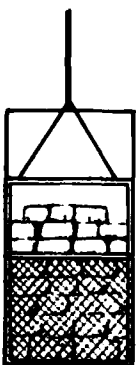
- Wait for the conveyance to be unloaded, then prepare to move the conveyance for the next job.

For summary, see Figure 1, page 22-3.



#### Lowering/Raising People

- Reduce rope speed.
- People and materials may not be raised or lowered at the same time in the same shaft during shift changes.

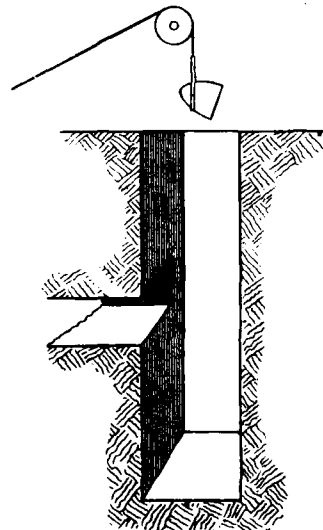
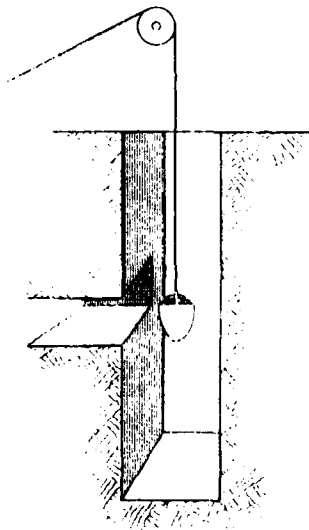


#### Raising Ore or Waste

##### Manual Operation

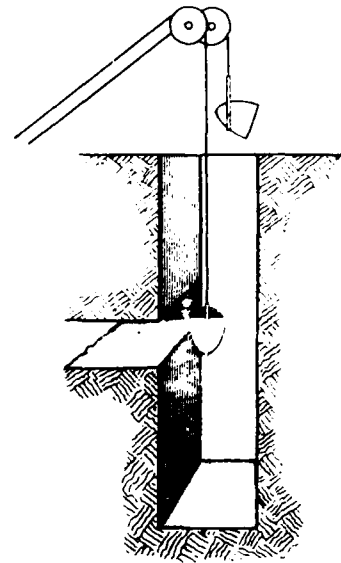
##### Single Level Mine — Single Skip Hoist

- Lower skip to work level
- Receive and interpret signal to hoist when skip is full
- Raise skip to dump level
- Hold skip at the dump with brake or low power application
- When skip is empty, lower to work level and repeat



#### Single Level Mine — Double Skip Hoist

- Lower one skip to the loading level; this action raises the other skip to the dump level.
- Raise the first skip to the dump level when it is full; this action lowers the second skip to the loading level.
- Repeat the first step when the first skip is dumped and the second skip is loaded.
- Minor adjustments to rope length may be necessary in order to have one skip at the loading level while the other is at the dump.



#### Multi-Level Mine — Double Skip Hoist (With Clutch)

- Raise one skip to the dump level; apply brake
- Disengage clutch and lower the second skip to the work level
- Re-engage clutch when second skip is in position and proceed as for Single Level Mine — Double Skip Hoist.

#### Automatic Operation

##### Automatic Elevators (for people)

- The people in the elevator select the destination level by pushing the correct button

##### Automatic Product Hoist (raising ore or waste)

- Lower skip manually to loading level
- Receive and interpret signal to hoist when skip is full
- Set hoist switch on AUTOMATIC
- Push START button

The hoist raises, dumps, lowers and loads until the STOP button is actuated.



## PRACTICE QUESTIONS FOR ROUTINE SHIFT ACTIVITIES

Complete this sentence with the correct answers:

1. The hoist operator's basic job is to move a/an \_\_\_\_\_ from one level to another quickly and \_\_\_\_\_.
2. A conveyance is moved in five steps; list them in order:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_
  - C. \_\_\_\_\_
  - D. \_\_\_\_\_
  - E. \_\_\_\_\_

Complete these sentences with the correct answers:

3. When hoisting people, the deadman switch is \_\_\_\_\_; when hoisting materials, the deadman bypass switch is \_\_\_\_\_.
4. To start the conveyance, apply power slowly and release the \_\_\_\_\_.
5. During acceleration the \_\_\_\_\_ and \_\_\_\_\_ must be kept within allowable limits.
6. To prevent excessive conveyance speed, the hoist operator uses the \_\_\_\_\_, electrical braking or the mechanical or hydraulic \_\_\_\_\_.
7. When the hoist operator reduces power and speed during deceleration, he/she watches the \_\_\_\_\_ and the \_\_\_\_\_.
8. As the conveyance approaches the destination, the hoist operator closely watches the markings on the \_\_\_\_\_ or \_\_\_\_\_ and brings the conveyance to a \_\_\_\_\_ speed.
9. The brake is set and power is cut off when \_\_\_\_\_.
10. When lowering or raising people, rope speed is \_\_\_\_\_.
11. People and materials may not be raised or lowered at the same time in the same shaft during \_\_\_\_\_.

Below are the steps for raising ore and waste manually or automatically. Choose the hoist operation that is similar to the one you will be operating. Fill in the blanks with the answer that best completes each sentence.

12. The hoist operator for a manual operation—single level mine, single skip hoist follows these steps when raising ore or waste:
  - A. Lower skip to \_\_\_\_\_ level.
  - B. Receive and interpret signal to hoist when \_\_\_\_\_.
  - C. Raise skip to \_\_\_\_\_ level.
  - D. Hold skip at dump with \_\_\_\_\_ or \_\_\_\_\_ application.
  - E. When skip is \_\_\_\_\_, lower to \_\_\_\_\_ level and repeat.
13. The hoist operator for a manual operation, single level mine-double skip hoist follows these steps when raising ore and waste:
  - A. Lower one skip to the loading \_\_\_\_\_; this raises the other skip to the \_\_\_\_\_ level.
  - B. Raise the first skip to the dump level when it is \_\_\_\_\_; this action lowers the second skip to the \_\_\_\_\_ level.
  - C. Repeat the first step when the first skip is \_\_\_\_\_ and the second skip is \_\_\_\_\_.
14. The hoist operator for a manual operation—multi-level mine, double skip hoist (with clutch) follows these steps when raising ore or waste:
  - A. Raise one skip to dump level; apply \_\_\_\_\_.
  - B. Disengage \_\_\_\_\_ and lower the second skip to the \_\_\_\_\_ level.
  - C. Re-engage \_\_\_\_\_ when second skip is in position.
  - D. Raise full skip to \_\_\_\_\_ level; lower \_\_\_\_\_ skip to work level.
  - E. Repeat the \_\_\_\_\_ procedure when the full skip is dumped and the empty skip is loaded.
15. When an automatic elevator is used, the people in the cage select their destination level by \_\_\_\_\_.

16. When the hoist is operated automatically, the hoist operator follows these steps to raise ore or waste:

- A. Lower skip \_\_\_\_\_ to loading level.
- B. Receive and interpret signal to hoist when skip is \_\_\_\_\_ .
- C. Set hoist switch on \_\_\_\_\_ .
- D. Push \_\_\_\_\_ button.

17. To stop an automatically operated hoist, the operator pushes the \_\_\_\_\_ .

## ANSWERS TO ROUTINE SHIFT ACTIVITIES PRACTICE QUESTIONS

1. conveyance; safely.
2. A. Start  
B. Accelerate  
C. Cruise  
D. Decelerate  
E. Stop
3. closed; closed.
4. brake.
5. current flow; rope speed
6. motor control; brake.
7. rope speed meter; depth indicator.
8. drum; depth indicator; very slow
9. the stop signal is received.
10. reduced.
11. shift changes.
12. A. work  
B. skip is full  
C. dump  
D. brake; low power  
E. empty; work
13. A. level; dump  
B. full; loading  
C. dumped; loaded
14. A. brake  
B. clutch; work  
C. clutch  
D. dump; empty  
E. loading

15. pushing the correct button.

16. A. manually  
B. full  
C. AUTOMATIC  
D. START

17. STOP button

# **MINE HOIST OPERATOR TRAINING PROGRAM**

## **UNIT 23**

# **EMERGENCY PROCEDURES**

## **OBJECTIVE**

The trainee will know the  
hoist operator's responsibilities  
during emergency situations

## **TIME**

**2**

## **TRAINING OBJECTIVES FOR EMERGENCY PROCEDURES**

The trainee will be able to answer in writing multiple-choice questions concerning emergency procedures.

The trainee will be able to describe emergency procedures.

Given a list of steps for each emergency procedure, the trainee will be able to number the steps in the order they are performed.

## EMERGENCY PROCEDURES

The hoist operator should know the procedures for emergency situations. These emergencies may be:

- Conditions in the hoist area that prevent safe operation of the hoist;
- Conditions in the mine that may endanger personnel underground but do not require evacuation;
- Conditions in the mine that require evacuation.

When an emergency occurs in the hoist area, the hoist operator is responsible for either correcting the situation or requesting the necessary assistance. Possible emergencies include:

- Loss of all power or of power to individual units—oil pump, hydraulic system, air compressor;
- Operational failures, overspeed, overtravel;
- Mechanical defects in hoist rope, operating linkages for brakes, clutch or motor controls;
- Electrical defects, high current, sparking, motor generator failure, electrical braking failure;
- Loss of (or low) hydraulic or pneumatic pressure.

The hoist operator's action, generally, will be as outlined in Pre-Shift Activities. These are repeated below.

- Low Power. To restore lost power, the hoist operator will: (See Figure 1)
  - Set the brake
  - Put the hoist control on OFF
  - Make sure the other machinery (hydraulic pump, air compressor, etc.) is switched off
  - Restore power
  - Restart other machinery

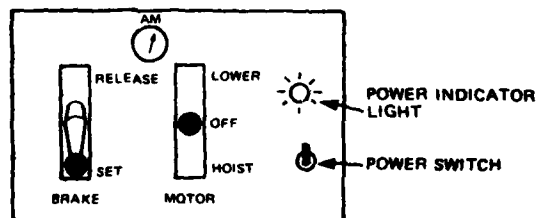


Figure 1



- Overtravel (top and bottom). To return the conveyance to the operating area, the hoist operator will: (See Figure 2)
  - Engage the overtravel bypass switch
  - Use the controller to move conveyance to within the operating area
  - Disengage the overtravel bypass switch

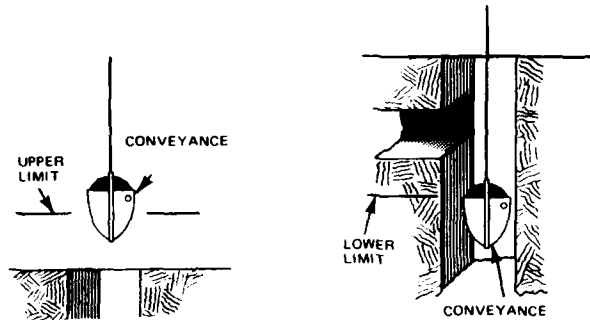


Figure 2

- Overspeed. To restore power to the hoist after the overspeed control cuts off power, the hoist operator will: (See Figure 3)
  - Set the brake
  - Put the controller in OFF
  - Reset POWER ON switch

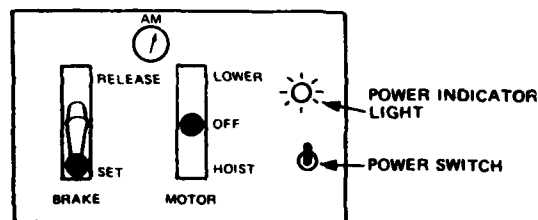


Figure 3

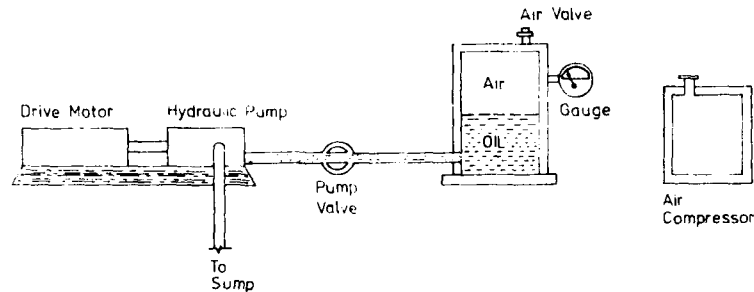
Repair of mechanical and/or electrical defects will probably be beyond the hoist operator's responsibilities. He/she will, therefore, normally request assistance. (See Figure 4)



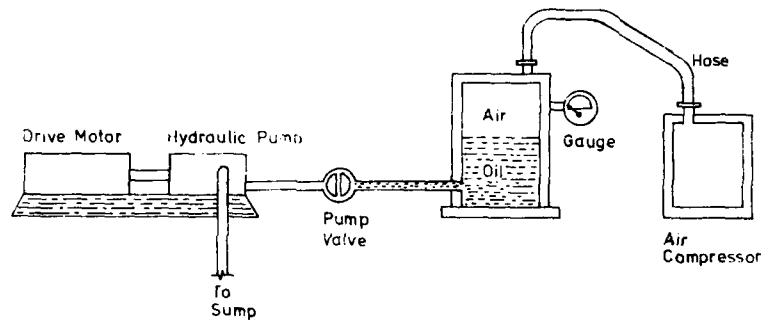
Figure 4

On some systems hydraulic pressure is maintained by compressed air. Periodically the air pressure falls off and must be restored. The hoist operator usually restores pressure by:

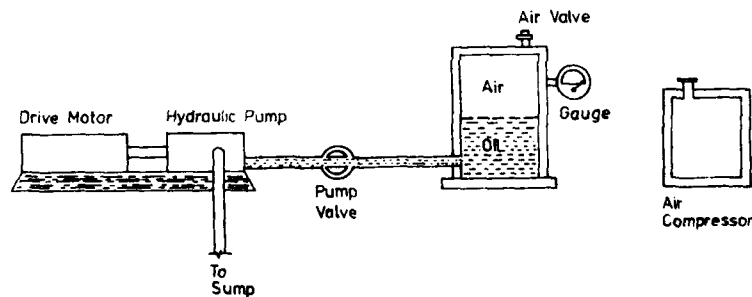
- Low Air Pressure on the Braking System. The hoist operator must be able to determine when the hydraulic system air pressure is low and why it is low. To restore or add air pressure, the hoist operator will:



- Stop the hydraulic pump and close the pump valve
- Open the air valve and bleed air from the reservoir



- Connect the compressor to the air reservoir
- Start the compressor and charge the air reservoir



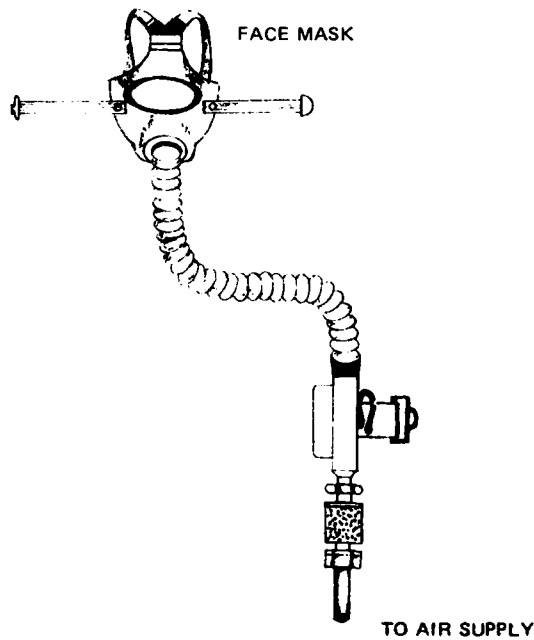
- Stop the compressor when the pressure is back to normal and disconnect it
- Restart the hydraulic pump.

In many mines the alarm for indicating emergencies that will affect other mine personnel is located at the hoist operator's station. It is his/her responsibility to alert the mine or shift foreman, the mine superintendent, and other personnel about situations such as:

- Ventilation failure
- Flooding
- Fire

He/she will then usually lower the conveyance to the working level and be ready to evacuate personnel.

When an emergency occurs which requires evacuation, it is the hoist operator's responsibility to operate the hoist until all personnel are clear of the endangered area. This situation requires that the operator remain at the hoist station for a considerable length of time. If the station is underground, the hoist operator will need a respirator with an independent air supply to use during the evacuation period. Below is an example of such a respirator:



In Part III you will learn your specific responsibilities in emergency situations, including how to use the air supply respirators if necessary.

## PRACTICE QUESTIONS FOR EMERGENCY PROCEDURES

Fill in the blanks with the correct answers.

1. Emergencies which may affect the hoist operator may be:
  - A. Conditions in the hoist area that prevent \_\_\_\_\_ ;
  - B. Conditions in the mine that don't require evacuation, but may endanger \_\_\_\_\_ ;
  - C. Conditions in the mine that require \_\_\_\_\_ .
2. The hoist operator is responsible for either \_\_\_\_\_ or \_\_\_\_\_ when emergencies occur in the hoist area.
3. Possible hoist area emergencies may be:
  - A. Loss of \_\_\_\_\_ pressure;
  - B. Mechanical defects in hoist \_\_\_\_\_ or operating linkages of the \_\_\_\_\_ , \_\_\_\_\_ , or \_\_\_\_\_ ;
  - C. Loss of all power or of power to individual units—oil \_\_\_\_\_ , hydraulic \_\_\_\_\_ , air \_\_\_\_\_ ;
  - D. Operational failures, \_\_\_\_\_ , \_\_\_\_\_ ;
  - E. Electrical defects, high \_\_\_\_\_ , sparking, motor \_\_\_\_\_ failure, electrical \_\_\_\_\_ failure.
4. To restore lost power, the hoist operator will:
  - A. Set the \_\_\_\_\_ ;
  - B. Put the hoist control on \_\_\_\_\_ ;
  - C. Make sure other machinery \_\_\_\_\_ , \_\_\_\_\_ is switched \_\_\_\_\_ ;
  - D. Restore \_\_\_\_\_ ;
  - E. Restart \_\_\_\_\_ .
5. To return the conveyance to the operating area of the shaft after overtravel, the hoist operator will:
  - A. Engage the \_\_\_\_\_ switch;
  - B. Use the controller to move the conveyance to \_\_\_\_\_ ;
  - C. Disengage the \_\_\_\_\_ switch.

6. To restore power to the hoist after the overspeed control has cut off power, the hoist operator will:
- A. Set the \_\_\_\_\_ ;
  - B. Put the controller in \_\_\_\_\_ ;
  - C. Reset \_\_\_\_\_ switch.
7. To restore or add air pressure to the braking system, the hoist operator will:
- A. Stop the \_\_\_\_\_ pump and close the \_\_\_\_\_ ;
  - B. Open the \_\_\_\_\_ valve and bleed \_\_\_\_\_ from the reservoir;
  - C. Connect the \_\_\_\_\_ to the air reservoir;
  - D. Start the compressor and charge the \_\_\_\_\_ ;
  - E. Stop the compressor and disconnect it when \_\_\_\_\_ ;
  - F. Restart the \_\_\_\_\_ .
8. In many mines it is the hoist operator's responsibility to sound the alarm for such emergencies as \_\_\_\_\_ failure, \_\_\_\_\_ , or \_\_\_\_\_ .
9. When an emergency requires evacuation, it is the hoist operator's responsibility to \_\_\_\_\_ the hoist until all personnel are \_\_\_\_\_ .
10. If the hoisting station is underground, the hoist operator will need \_\_\_\_\_ to use during the evacuation period.

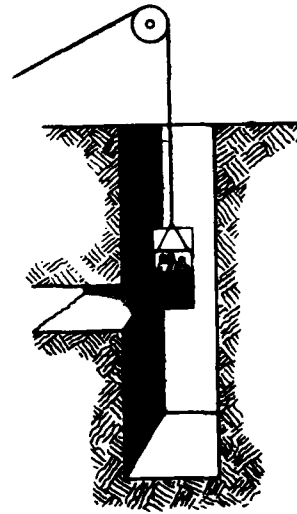
## ANSWERS TO EMERGENCY PROCEDURES PRACTICE QUESTIONS

1. A. safe operation of the hoist;  
B. personnel underground;  
C. evacuation.
2. correcting the situation; requesting assistance
3. A. hydraulic  
B. rope; brakes; clutch; motor controls;  
C. pump; system; compressor;  
D. overspeed; overtravel;  
E. current; generator; braking
4. A. brake  
B. OFF  
C. hydraulic pump; air compressor; off  
D. power  
E. other machinery
5. A. overtravel bypass  
B. within the operating area  
C. overtravel bypass
6. A. brake  
B. OFF  
C. POWER ON
7. A. hydraulic; pump valve  
B. air; air  
C. compressor  
D. air reservoir  
E. the pressure is back to normal  
F. hydraulic pump
8. ventilation; flooding; fire
9. operate; clear of the endangered area
10. a respirator with an independent air supply

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 24

### END OF SHIFT ACTIVITIES



#### OBJECTIVE

The trainee will know the hoisting activities  
that are performed at the end of the shift

#### TIME

1/2

## **INSTRUCTIONAL OBJECTIVES FOR END OF THE SHIFT ACTIVITIES**

The trainee will be able to describe in writing the activities to be performed at the end of the shift.

1. The trainee will be able to answer multiple choice questions about the end of shift activities.
2. The trainee will be able to give in order the steps for securing the conveyance.

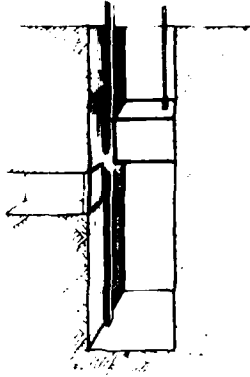


## END OF SHIFT ACTIVITIES

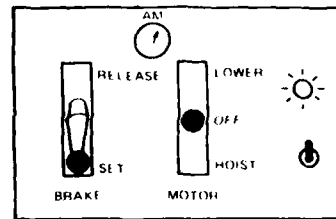
At the end of the shift, the hoist operator places the hoist in a release state. This requires moving the conveyance clear of the landing levels, securing the conveyances, and entering information in the log.

The hoist operator will:

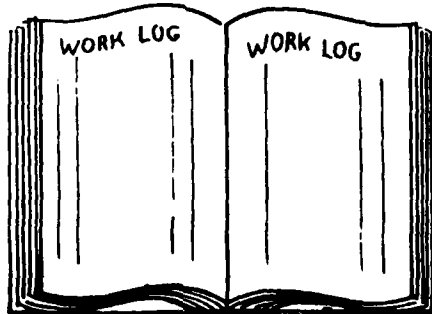
- Move the conveyances to mid-shaft position, clear of the landing level;



- Secure the conveyances
  - Set brake
  - Set motor control on OFF
  - Check that conveyances balance
  - Turn power switch off



- Record hoist condition and problems encountered during the shift in the log.



## PRACTICE QUESTIONS FOR END OF SHIFT ACTIVITIES

Complete these sentences with the correct answers:

1. The hoist operator places the hoist in a \_\_\_\_\_ state at the end of the shift.
2. The hoist operator moves the conveyances to \_\_\_\_\_, clear of the \_\_\_\_\_ level.
3. To secure the conveyances, the hoist operator will:
  - A. Set the \_\_\_\_\_.
  - B. Set the motor control on \_\_\_\_\_.
  - C. Check that the conveyances \_\_\_\_\_.
  - D. Turn the power switch \_\_\_\_\_.
4. The hoist operator records \_\_\_\_\_ and \_\_\_\_\_ in the log at the end of the shift.

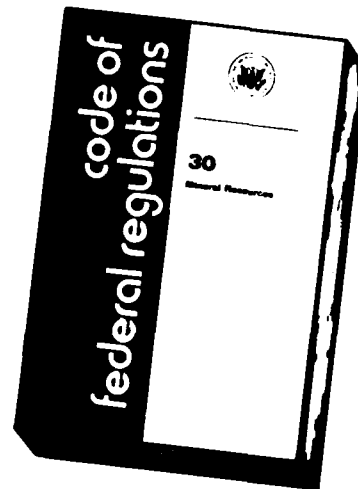
### ANSWER TO END OF SHIFT PRACTICE QUESTIONS

1. release
2. mid-shaft position; landing
3.
  - A. brake
  - B. OFF
  - C. balance
  - D. OFF
4. problems encountered during the shift; the hoist condition

# MINE HOIST OPERATOR TRAINING PROGRAM

## UNIT 25

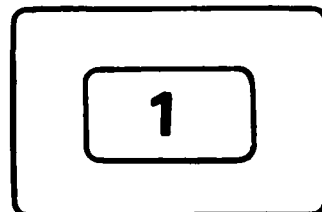
# FEDERAL REGULATIONS FOR HOISTING PROCEDURES



## OBJECTIVE

The trainee will know the federal regulations  
that apply to hoisting procedures

## TIME



## **TRAINING OBJECTIVES FOR HOISTING PROCEDURE FEDERAL REGULATIONS**

The trainee will be able to describe the federal regulations for hoisting procedures.

1. The trainee will be able to answer multiple-choice questions about the federal regulations for hoisting procedures.
2. The trainee will be able to answer fill in the blank questions for hoisting procedures.

## **FEDERAL REGULATIONS FOR HOISTING PROCEDURES (From Title 30 CFR)**

### **Metal and Nonmetallic Mines**

#### **HOISTING PERSONNEL**

57.19-55 *Mandatory*. When a manually operated hoist is used, a qualified hoistman shall remain within hearing of the telephone or signal device at all times while any person is underground.

57.19-56 *Mandatory*. When automatic hoisting is used, a competent operator of the hoist shall be readily available at or near the hoisting device while any person is underground.

57.19-57 *Mandatory*. No person shall operate a hoist unless within the preceding 12 months he has had a medical examination by a qualified, licensed physician who shall certify his fitness to perform this duty. Such certification shall be available at the mine.

57.19-58 *Mandatory*. Only experienced hoistmen shall operate the hoist except in cases of emergency and in the training of new hoistmen.

57.19-63 *Mandatory*. Only authorized persons shall be in hoist rooms.

57.19-67 *Mandatory*. During shift changes, an authorized person shall be in charge of each trip in which persons are hoisted.

#### **RIDING IN THE CONVEYANCE**

57.19-66 *Mandatory*. In shafts inclined over 45 degrees, the operator shall determine and post in the conveyance at each shaft station the maximum number of persons permitted to ride in a hoisting conveyance at any one time. Each person shall be provided a minimum of 1.5 square feet of floor space.

57.19-68 Men shall enter, ride, and leave conveyances in an orderly manner.

57.19-69 *Mandatory*. Men shall not enter or leave conveyances which are in motion or after a signal to move the conveyance has been given to the hoistman.

57.19-70 *Mandatory*. Cage doors or gates shall be closed while men are being hoisted; they shall not be opened until the cage has come to a stop.

57.19-71 *Mandatory*. Men shall not ride in skips or buckets with muck, supplies, materials, or tools other than small hand tools.

57.19-74 *Mandatory*. Persons shall not ride the bail, rim, bonnet, or crosshead of any shaft conveyance except when necessary for inspection and maintenance, and then only when suitable protection for persons is provided.

#### **RAISING AND LOWERING MEN**

57.19-60 Hoistmen shall use extreme caution when hoisting or lowering men.

57.19-61 The safe speed for hoisting men shall be determined for each shaft, and this speed shall not be exceeded. Men shall not be hoisted at a speed faster than 2,500 feet per minute, except in an emergency.

57.19-76 *Mandatory.* When men are hoisted in buckets, speeds shall not exceed 500 feet per minute and shall not exceed 200 feet per minute when within 100 feet of the intended station.

#### GENERAL HOISTING

57.19-62 *Mandatory.* Maximum normal operating acceleration and deceleration shall not exceed 6 feet per second per second. During emergency braking, the deceleration shall not exceed 16 feet per second per second.

57.19-65 *Mandatory.* Conveyances shall not be lowered by the brakes alone except during emergencies.

57.19-72 *Mandatory.* When combinations of cages and skips are used in the same compartment, the cages shall be enclosed to protect personnel from flying material and the hoist speed reduced to man-speed as defined in section 57.19-61, but not to exceed 1,000 feet per minute. Muck shall not be hoisted with personnel during shift changes.

57.19-73 *Mandatory.* Rock or supplies shall not be hoisted in the same shaft as men during shift changes, unless the compartments and dumping bins are partitioned to prevent spillage into the cage compartment.

57.19-75 *Mandatory.* Open hooks shall not be used to hoist buckets or other conveyances.

57.19-77 *Mandatory.* Buckets shall be stopped about 15 feet from the shaft bottom to await a signal from one of the crew on the bottom for further lowering.

57.19-78 *Mandatory.* All buckets shall be stopped after being raised about three (3) feet above the shaft bottom. A bucket shall be stabilized before a hoisting signal is given to continue hoisting the bucket to the crosshead. After a hoisting signal is given, hoisting to the crosshead shall be at the minimum speed. The signaling device shall be attended constantly until a bucket reaches the guides. When persons are hoisted, the signaling devices shall be attended until the crosshead has been engaged.

57.19-79 *Mandatory.* Where mine cars are hoisted by cage or skip, means for blocking cars shall be provided at all landings and also on the cage.

57.19-80 *Mandatory.* When tools, timbers or other materials are being lowered or raised in a shaft by means of a bucket, skip, or cage, they shall be secured or so placed that they will not strike the sides of the shaft.

#### PLACING THE CONVEYANCE IN A RELEASE STATE

57.19-81 *Mandatory.* When conveyances controlled by a hoist operator are not in use, they shall be released and the conveyances shall be raised or lowered a suitable distance to prevent persons from boarding or loading the conveyances.

### **Underground Coal Mines**

75.1400 Where persons are transported into, or out of, a coal mine by hoists, a qualified hoisting engineer shall be on duty while any person is underground, except that no such engineer shall be required for automatically operated cages, platforms, or elevators.

### **HOISTING PROCEDURES**

75.1403-3 (f) An attendant shall be on duty at the surface when men are being hoisted or lowered at the beginning and end of each *operating shift*.



## PRACTICE QUESTIONS FOR HOISTING PROCEDURES

### Metal and Nonmetallic Mines

Complete these sentences with the correct answers:

#### HOISTING PERSONNEL

1. 57.19-55 *Mandatory*. When a manually operated hoist is used, a qualified hoistman shall remain within hearing of the \_\_\_\_\_ or \_\_\_\_\_ at all times while any \_\_\_\_\_ is underground.
2. 57.19-56 *Mandatory*. When automatic hoisting is used, a competent \_\_\_\_\_ shall be readily available at or near the hoisting device while any person is \_\_\_\_\_.
3. 57.19-57 *Mandatory*. No person shall operate a hoist unless within the preceding 12 months he has had \_\_\_\_\_ by a qualified, licensed physician who shall certify his fitness to perform this duty. Such certification shall be available \_\_\_\_\_.
4. 47.19-58 *Mandatory*. Only \_\_\_\_\_ operate the hoist except in cases of \_\_\_\_\_ and in the training of hoistmen.
5. 57.19-63 *Mandatory*. Only \_\_\_\_\_ persons shall be in hoist rooms.
6. 57.19-67 *Mandatory*. During shift changes an \_\_\_\_\_ person shall be in charge of each man trip in which persons are hoisted.

#### RIDING IN THE CONVEYANCE

7. 57.19-66 *Mandatory*. In shafts inclined over 45 degrees, the operator shall determine and post in the conveyance or at each shift station the \_\_\_\_\_ permitted to ride in a hoisting conveyance at any one time. Each person shall be provided a minimum of \_\_\_\_\_ square feet of floor space.
8. 57.19-68 Men shall enter, ride, and leave conveyances in an \_\_\_\_\_.
9. 57.19-69 *Mandatory*. Men shall not enter or leave conveyances which \_\_\_\_\_ or after a signal to \_\_\_\_\_ has been given to the hoistman.

10. 57.19-70 *Mandatory*. Cage doors or gates shall be \_\_\_\_\_ while men are being hoisted; they shall not be opened until the cage has \_\_\_\_\_.
11. 57.10-71 *Mandatory*. Men shall not ride in skips or buckets with \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, or tools other than small hand tools.
12. 57.19-74 *Mandatory*. Persons shall not ride the \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, or \_\_\_\_\_ of any shaft conveyances except where necessary for inspection and maintenance; and then only when \_\_\_\_\_ for persons is provided.

#### RAISING AND LOWERING MEN

13. 57.19-60 Hoistmen shall use extreme caution when hoisting or lowering \_\_\_\_\_.
14. 57.19-61 The safe speed for hoisting men shall be determined for each shaft, and this speed shall \_\_\_\_\_. Men should not be hoisted at a speed faster than \_\_\_\_\_, except in an emergency.
15. 57.19-76 *Mandatory*. When men are hoisted in buckets, speeds shall not exceed \_\_\_\_\_ per minute and shall not exceed 2000 feet per minute when within 100 feet of \_\_\_\_\_.

#### GENERAL HOISTING

16. 57.19-62 *Mandatory*. Maximum normal operating acceleration and deceleration shall not exceed \_\_\_\_\_ per second per second. During emergency braking, the deceleration shall not exceed \_\_\_\_\_ per second per second.
17. 57.19-65 *Mandatory*. Conveyances shall not be lowered by the brakes alone \_\_\_\_\_.
18. 57.19-72 *Mandatory*. When combinations of cages and skips are used in the same compartment, the cages shall be \_\_\_\_\_ to protect personnel from flying material and the hoist speed reduced to manspeed but not to exceed \_\_\_\_\_. \_\_\_\_\_ shall not be hoisted with personnel during shift changes.

19. 57.19-73 *Mandatory*. Rock or supplies shall not be hoisted in the same shaft as \_\_\_\_\_ during shift changes, unless the compartments and dumping bins are partitioned to prevent spillage into the \_\_\_\_\_.
20. 57.19-75 *Mandatory*. \_\_\_\_\_ shall not be used to hoist buckets or other conveyances.
21. 57.19-77 *Mandatory*. Buckets shall be stopped about 15 feet from \_\_\_\_\_ to await a signal from one of the crew on the bottom for further lowering.
22. 57.19-78 *Mandatory*. All buckets shall be stopped after being raised about \_\_\_\_\_ above the shaft bottom. A bucket shall be stabilized before a hoisting signal is given to continue hoisting the bucket to the crosshead. After a hoisting signal is given, hoisting to the crosshead shall be at the \_\_\_\_\_. The signaling device shall be attended constantly until a bucket \_\_\_\_\_. When persons are hoisted, the signaling devices shall be attended until the \_\_\_\_\_ has been engaged.
23. 57.19-79 *Mandatory*. Where mine cars are hoisted by cage or skip, means for blocking cars shall be provided at \_\_\_\_\_ and also on the \_\_\_\_\_.
24. 57.19-80 *Mandatory*. When \_\_\_\_\_, \_\_\_\_\_ or other materials are being lowered or raised in a shaft by means of a bucket, skip, or cage, they shall be secured or so placed that they will not strike the sides of the \_\_\_\_\_.

#### PLACING THE CONVEYANCE IN RELEASE STATE

25. When conveyances controlled by a hoist operator are not in use, they shall be released and the conveyances shall be \_\_\_\_\_ or \_\_\_\_\_ a suitable distance to prevent persons from \_\_\_\_\_ or \_\_\_\_\_ the conveyances.

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MINE HOIST OPERATOR TRAINING PROGRAM. INSTRUCTION MANUAL.(U)  
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### **Underground Coal Mines**

26. 75.1400 Where persons are transported into, or out of, a coal mine by hoists, a \_\_\_\_\_ shall be on duty while any \_\_\_\_\_ is underground, except that no such engineer shall be required for automatically operated cages, platforms, or elevators.

### **HOISTING PROCEDURES**

27. 75.1403-3 (f) An \_\_\_\_\_ shall be on duty at the surface when men are being hoisted or lowered at the beginning and end of each \_\_\_\_\_.

## ANSWERS TO FEDERAL REGULATIONS PRACTICE QUESTIONS

1. telephone; signal device; person
2. operator of the hoist; underground.
3. a medical examination; at the mine.
4. experienced hoistmen; emergency
5. authorized
6. authorized
7. maximum number of persons; 1.5
8. orderly manner.
9. are in motion; move the conveyance
10. closed; come to a stop
11. muck, supplies, materials
12. bail, rim, bonnet; crosshead; suitable protection
13. men.
14. not be exceeded. 2,500 feet per minute
15. 500 feet; the intended station.
16. 6 feet; 16 feet
17. except during emergencies.
18. totally enclosed; 1,000 feet per minute; Muck
19. men; cage compartment.
20. Open hooks
21. the shaft bottom
22. three (3) feet; minimum speed. reaches the guides. crosshead
23. all landings; cage.

- 24. tools, timbers; shaft.
- 25. raised; lowered; loading; boarding
- 26. qualified hoisting engineer; person
- 27. attendant; operating shift.

